THE

AMERICAN ORTHOPTIC JOURNAL

1953

VOLUME 3

Official Organ of

AMERICAN ASSOCIATION

of

ORTHOPTIC TECHNICIANS

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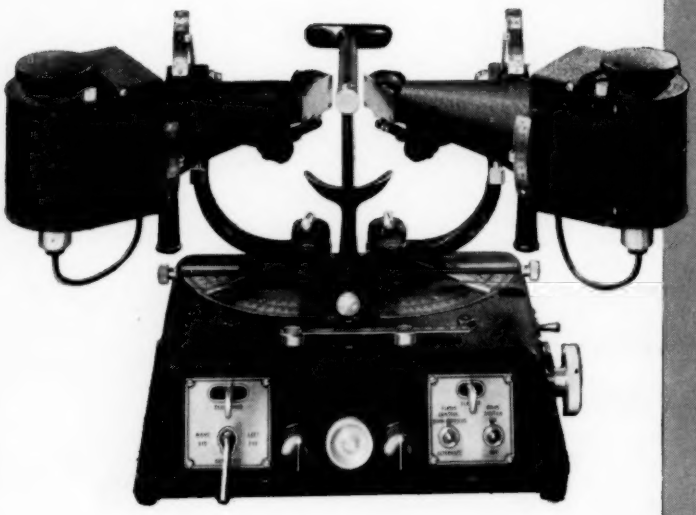

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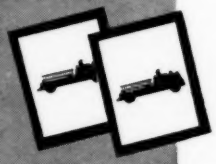

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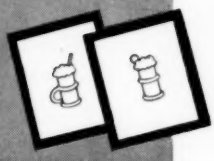

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PRINTED IN OMAHA, NEBRASKA
BY
DOUGLAS PRINTING COMPANY
PRINTED IN U.S.A.

PHYSIOPATHOLOGY

WALTER H. FINK, M.D.
MINNEAPOLIS, MINN.

CONVERGENCE insufficiency is of great clinical importance. It was first described in 1862 by von Graefe and has continued throughout the years to occupy a prominent place in ophthalmic literature. In spite of the fact that it is a fairly common condition, there still exists much controversy as to its exact nature. A study of the literature emphasizes the various interpretations which have been made concerning it and even today opinion varies as to the fundamental process involved. It seems worth while therefore, to assemble various data concerning it with the hope of crystallizing opinion. My purpose is to consider one phase of the subject, namely the physiopathology of convergence insufficiency. The subject will be considered from two aspects: the mechanism involved and the pathologic manifestation.

THE MECHANISM INVOLVED

Developmental Basis

An understanding of the convergence mechanism is dependent upon a knowledge of the development of the earlier binocular reflexes. According to Duke-Elder all nervous activities are reflex in nature and may be divided into two classes: unconditioned reflexes, which are simple reflex activities of the cord and brain stem, and conditioned reflexes, which are due to cerebral activity and superimposed upon the unconditioned reflexes, provided the structural basis has developed. The unconditioned reflexes occur with great regularity and are dependent to a great degree on heredity. In contrast the conditioned reflexes are acquired and are dependent upon the individual experience and environment. Although the unconditioned reflex is a necessary precursor of the conditioned reflex, with proper development the conditioned reflex can become as firmly established as unconditioned reflexes.

Therefore, in the evolutionary development of the binocular reflexes we have primarily the unconditioned postural reflexes from which the conditioned visual fixation reflexes are developed, and a later differentiation of the conjugate, disjunctive and corrective reflexes out of the fixation reflex.

The postural reflex is an unconditioned reflex which is dependent upon a subcortical involuntary reflex mechanism. It is completed before birth in man. It functions independently of ocular stimuli and the labyrinths and muscles of the neck are the end organs. The normal development of the higher binocular reflexes, which are related to retinal stimulation, are dependent upon the presence of the postural reflex.

The fixation reflex develops at a later stage of evolution. In humans it is present at birth but is only feebly developed.

Read at the annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 14, 1952, Chicago, Ill.

The eyes are oriented about the fixation point on a visual rather than a postural basis.

The conjugated fixation reflex is evident at the age of 6 weeks and is sufficiently established so that the eyes follow a point of interest when it changes its position. After 6 months conjugate fixation is maintained throughout all excursions in spite of obstacles, and one eye will deviate when a prism is interposed in its path. In its ultimate development, it becomes adapted to voluntary control.

Corrective fusion reflex. The corrective fusion reflex is firmly established toward the end of the first year, at the age when the maculas have also developed. The process by which it is acquired is like that of other habits, a facilitation of reflex paths. It is built up by education and practice, but not to the same extent in all persons. The corrective fusion reflex develops to compensate for maladjustments and to maintain parallelism of the visual axes allowing fusion even in conditions of stress.

The fusion mechanism develops with daily usage and by the time a child reaches the age of 5½ to 6 years, the fusion mechanism is fairly mature, provided development of the binocular neuromuscular mechanism has been normal.

The disjunctive (convergence and divergence) movements of the eyes are the last refinement of binocular activity to be acquired, corresponding to their late phylogenetic development. They are acquired so late in evolution that they are seen fully developed only in man. Because of this refinement, stereoscopic vision at all distances up to the near point is made possible.

Convergence of the eyes is rarely seen before the age of one month. Infants show very little convergence until the third month of life. At 6 months it is well developed and of considerable range. As the child grows older, his automatic controls over the convergence are perfected and voluntary control makes its appearance. When this occurs, the excess of convergence present early in life is brought under adequate control.

Precision in fixation, however, is not achieved until somewhat later, when wider experience, as well as better development of the visual tracts, makes more efficient vision possible. When the visual tracts have been myelinated sufficiently to permit binocular vision, the function of fusional vergence must be developed to ensure that it be also single because diplopia is apparently repugnant to the human organism.

In keeping with what may be expected of a phylogenetically young reflex, the convergence mechanism is unstable and anomalies are frequently present. However, it is very adaptable and responds to training.

Accommodation and convergence are not associated during the infant's early development. Although a high degree of convergence is possible in the early months of life, an appreciable degree of accommodation is not possible. Accommodation is only developed up to the limit of visual acuity which may be present. In the first few months of life visual acuity is poorly developed, but it develops rapidly between the ages of 6 months and 2½ years, at which time the visual acuity for distance approaches the adult level. The range and accuracy of accommodation undergo parallel development with vision. As visual acuity increases, accommodation is gradually developed to the level of convergence. With a higher degree of visual acuity and a well-developed and more accurate accommodation, the vergence reflex shows a correspondingly greater development and accuracy.

A frequent source of trouble is lack of harmony between the two habitually coordinated functions of convergence and accommodation. In the presence of an appreciable refractive error some disruption is inevitable.

Anatomic Basis

Cortical region. Very little is known about the neuroanatomy of convergence movements of the eyes. Evidence indicates that the central control mechanism differs from that associated with the conjugate movements. Because of their voluntary as well as reflex nature, it is logical to assume that more than one center is designated for their function. There is some evidence to substantiate the opinion that voluntary convergence is initiated in the cortex of the second prefrontal gyrus, while involuntary convergence begins in the occipital cortex. However, these cortical centers are as yet poorly understood.

Subcortical region. Abundant experimental and clinical evidence has shown that convergence may be retained with extensive lesions of the pons and of the medial longitudinal fasciculus. Hence it is reasonable to infer that the corticofugal pathways for convergence reach the oculomotor nuclei along the anterior brachia and superior colliculi rather than by way of the pons. This accounts for the frequent dissociation of convergence and conjugate lateral movements with lesions in various parts of the brain stem. Also, the frequency with which lesions in the vicinity of the superior colliculi are accompanied by paralysis of convergence (along with fixed pupils and palsies of conjugate vertical gaze) leads one to suspect that the subcortical center for convergence is in the area of the superior colliculi.

Nuclear mechanism. Perlia's nucleus, the unpaired group of motor cells lying between the third nerve nuclei, is generally supposed to be a center for convergence, since it develops phylogenetically along with the function of convergence. There is, however, no direct evidence that it serves convergence exclusively.

Physiology of Convergence

Convergence is the faculty of increasingly adducting each eye, simultaneously and synchronously, in order to maintain bifoveal fixation while the object of attention approaches the eyes or while increasing temporal disparity is introduced between the two eyes. For purposes of analysis and to facilitate clinical investigation convergence may be divided into involuntary and voluntary convergence.

Involuntary convergence. Convergence is primarily an involuntary function. It is a psycho-optical reflex based upon the fixation and refixation reflexes, that is, it is dependent upon the perceptual appreciation of fixation and requires attention.

Involuntary convergence may be divided into four components in terms of the source of the stimuli which produce it. Named according to the chief causal factor in their production, these are known as the tonic, fusional, accommodative, and proximal reflexes. Each of these components, with the possible exception of the proximal, seems to be independent.

Tonic convergence. Tonic convergence is that angular relationship between the two visual axes which results from the habitual distribution of tonic innervation to the two ocular muscle groups. It is the convergence necessary to maintain parallelism of the visual lines in primary position and distance fixation in order to neutralize the slight divergence which is the normal position of the eyes. It is actually a state of compensatory tonic innervation and, as such, part of fusional convergence

("basic fusional tonus"), differing in amount in various individuals with their exophoria for distance.

Tonic convergence brings the eyes from some unknown position to the position they occupy as disclosed by the heterophoria test with fixation at 6 meters.

Tonic convergence does not appear to be simple, and our present state of knowledge does not allow us to speak with any certainty as to the nature of this particular aspect of convergence. It is of a static nature and its value appears to depend on such factors as the amount of light striking each retina and neural impulses arising in the cortex, the otoliths, the labyrinths, the neck and the trunk.

Fusional convergence. Fusional convergence may be defined as the response to increasing temporal disparity outside of Panum's areas. It is a positive vergence produced by stimulation of the retinal perimacular and extramacular fusional receptors, and it has for its object the establishment and maintenance of single binocular vision. It is this corrective movement which causes visual lines of gaze to change direction and position so that object points in space imaged on disparate retinal elements will be shifted onto corresponding retinal elements.

Fusional convergence adds itself to the tonic vergence reflexes in order to provide for near vision and is ordinarily responsible for fixation and single binocular vision at the near point. It is as a result of this reflex that the eyes are directed to objects of interest and maintained in the necessary orientation to ensure that the images formed by the two eyes fall on the foveas. The extent of the influence of this reflex is seen if fusion is abolished at the near point by occluding one eye, whereupon the covered eye deviates outward.

Recent work suggests that the fusional convergence is chiefly responsible for the adaptability and flexibility of the convergence-accommodation relationship and that the accommodation-convergence factor is comparatively static.

Fusion convergence depends on the integrity and efficiency of the reflex pathways which originate in the retinal receptors, continue to the cortical and subcortical fusion centers, where the neural impulses are received and the sensation of diplopia reaches consciousness. From the visual centers the efferent impulses to correct the diplopia pass to the optic motor centers, the supranuclear centers, the motor nuclei, the peripheral nerves and the muscles.

Accommodative convergence. Accommodative convergence has been defined by Tait as that positive vergence which, under certain conditions, results from accommodative activity reflexly superseding the underlying tonic reciprocal innervations. It is an associated reflex consisting of convergence of the eyes, contraction of the ciliary muscle, and constriction of the pupils of both eyes.

In order to maintain single binocular vision where an object is brought close to the eyes it is necessary that there be exactness of accommodation for clear vision and precision of movements of the eyes for accurate positioning of each eye so that its visual axis is directed toward the object of regard. The accommodation required is supplied by the retinal accommodation reflex of either or both of the eyes, while the convergence movements of the eyes are brought about by the subconscious demand for single vision, expressed through a stimulus-response mechanism which may be called the fusional convergence reflex. Therefore, the effective stimulus for accommodation is indistinctness of vision or blurring of

the retinal images and the effective stimulus for convergence is diplopia. Barring accident or disease, these reflexes continue to function throughout life, even though the retinal accommodation reflex becomes less efficient with the onset of presbyopia.

If the fusional vergence power is disrupted by design or because of a recently developed ocular anomaly, convergence is made dominant and is free to respond to the accommodative stimulation.

The exact nature of the accommodation-convergence reflex is not known. It is generally accepted that in ordinary binocular vision there is a perfect concert between accommodation and convergence, so that the two visual axes meet exactly at whatever point is accommodated for. Convergence and accommodation are linked so that a change in the one produces a change in the other. With the normal eyes, this linkage ensures that the accommodation and convergence are appropriate for any given distance of the object.

However, in abnormal accommodative or convergence problems the relation between the two functions is not so clear. Some believe that although the two synkinetic functions of accommodation and convergence are normally closely interrelated, the relation between them is elastic and either can be exercised separately. They believe that a dissociation of the two is necessary in all forms of ametropia. The uncorrected hypermetrope has to use his accommodation in excess of his convergence, and the myope his convergence in excess of his accommodation. Also, convergence continues although the accommodation has failed in the presbyope or if the ciliary muscle has been paralyzed by atropine.

According to other observers there is a plausible explanation of these phenomena other than a dissociation of accommodation and convergence. Their investigations seem to indicate that accommodative convergence is extremely stable in any one subject. Morgan points out that binocular vision with changes in emmetropia and correction lenses is made possible not by a dissociation of the functions of accommodation and convergence, but by a variation in relative fusional convergence. Relative fusional convergence makes up any excess or deficiency of the other two, so that single binocular vision can be maintained. Thus, fusional convergence can be positive, in making up a deficiency, or negative, in reducing an excess.

Proximal convergence. Proximal convergence is an association reflex of the same type as accommodative convergence, except that its primary stimulus is the sense of nearness, or proximal sense, rather than the use of accommodation.

Proximal convergence can also be demonstrated and measured. In order to do so, it is necessary to neutralize the fusional vergence and the accommodative convergence reflexes, because these are usually so considerably greater in amount that when either is present it supersedes the proximal reflex. With fixation at near, dissociation to abolish the fusional vergence reflex, and sufficient lens power in place to relieve accommodation, any positive convergence other than that which is present in the tonic vergence balance at distance represents the proximal stimulatory effect on the convergence mechanisms. Removal of the stimulus to a greater distance, keeping the reflexes under control, will reduce the convergence ultimately to the tonic level.

Proximal convergence is of importance when evaluating findings with machines such as the major ambly-

oscope, and is quite obviously a factor in all tests of heterophoria at the near distance.

Voluntary convergence. Voluntary convergence involves the volitional rotation of the eyes nasalward. It is the only disjunctive movement which can be initiated at will. It may be either the ability to rotate the eyes nasalward voluntarily without the assistance of a fixation object or the involuntary components of convergence function or the ability to maintain the eyes in adducted position without the aid of a fixation object.

The majority of persons acquire slight voluntary control over convergence, but few actually have much facility since this control is seldom used. Even in the adult it is seldom present as a purely voluntary act without some training. The majority of individuals if asked to converge cannot do so without some fixation point on which to fasten their attention. The presence of such a point brings into play the involuntary part of convergence. It may in some instances after training be voluntarily dissociated from its synergic link with accommodation. It is to be noted that the ability to converge voluntarily does not necessarily indicate a high involuntary converging power. It is probably linked to proximal convergence.

PATHOLOGIC ASPECTS

Convergence insufficiency should not be confused with paralysis of convergence resulting from organic disease. True convergence paralyses are rare and will not be considered in this presentation.

There is no unanimity of opinion as to just what constitutes a convergence insufficiency.

The Duane-White viewpoint is that a case of convergence insufficiency is one in which there is little or no heterophoria for distance fixation but a marked exophoria with fixation at one-third meter. It further considers that the condition may be due to direct weakness of the interni or that it may be secondary to a divergence excess (high exophoria for distance).

Duane noted that refractive errors may have something to do with this situation in that there were variations in uncorrected myopia or hyperopia or in early presbyopia. He also noted that unsuitable surgical interference and insufficiencies of elevator or depressor muscles may give rise to an apparent convergence insufficiency.

However, a study of the anatomic and physiologic factors involved suggests a different interpretation. There is evidence to justify the contention that convergence insufficiency is an inadequate convergence due to a deficiency in fusional convergence. It is more appropriately called fusional vergence insufficiency and can be diagnosed on the basis of an inadequate fusional convergence amplitude.

Cases of convergence insufficiency may exist as a separate clinical entity, unassociated with exophoria or esophoria, or it may exist in association with either, or with hyperphoria.

Scobee stated:

> One could write a great deal on possible interpretations of convergence insufficiency. My own belief is that the most important single criterion of convergence insufficiency is just that—poor convergence amplitudes on a major amblyoscope (preferably) or with a rotary prism. It is much more common to find poor convergence amplitudes at near than at far. My own studies have shown that the mean convergence power of the naive subject is about 20 prism diopters at far and slightly less than this is necessarily associated with symptoms. I have seen a number of patients with less than 10 diopters of convergence at both near and far who had no foveal suppression and yet were perfectly comfortable

In this view convergence insufficiency is largely an anomaly of the vergence movements. Deficiencies of voluntary convergence should, therefore, be differentiated from convergence insufficiency. Voluntary convergence is independent of the fusional vergence. It may be absent or poorly developed and the fusional convergence normal; or vice versa, voluntary convergence may be well developed, but the fusional vergence may be deficient. The near point of convergence as usually determined is, therefore, not a reliable guide in diagnosing convergence insufficiency. It is not rare to find patients whose near point of convergence is close and yet whose prism convergence at near is definitely subnormal, or, conversely, patients whose near point of convergence is remote yet whose prism convergence at the near point is well within normal limits.

Convergence insufficiency should also be differentiated from static exophoria wherein the deviation is relatively constant for all distances and from divergence excess, discussed at last year's symposium.

Etiology

The factors which produce convergence insufficiency are not clearly understood. The functional factor (psychogenic in origin) is usually considered to be an important causative factor. That the condition is frequently dependent on a neurogenic basis is suggested by the occurrence or recurrence of symptoms without any objective changes, and their persistence after the physical condition has been cured or their disappearance although the physical condition remains unaltered. It is a highly variable entity, being at times quite obvious and at other times entirely absent. Such an individual may make out fairly well if he does not do too much close work.

The functional factor is a result and, at the same time, a cause of nervous tension, thus setting up a vicious circle. It is by no means clear what is the horse and what is the cart, i.e., whether some people have convergence insufficiency because they are neurotics or whether they have neurotic traits because they have a convergence insufficiency.

In addition to the functional factor, other causes of convergence insufficiency have been suggested.

1. Delayed development of a lately acquired function is considered by some to be an etiologic factor in certain instances.

2. Anatomic abnormalities, such as wide interpupillary distance, may make convergence difficult and are considered a factor.

3. The amplitude of fusional vergence is generally lowered by the debility caused by severe or chronic illness, or by the presence of endogenous or exogenous toxins, or other metabolic disorders.

4. An insufficiency from disuse may be seen in those who cannot see clearly at close distances and therefore do not call up convergence habitually, such as marked hypermetropes, anisometropes or presbyopes. In the case of an amblyopic or blind eye this deficiency owing to disuse may amount to a pseudoparalysis of convergence, a condition which, as we have seen, may slowly evolve from a periodic into a permanent divergent squint.

5. If this reflex synergy has been developed and if accommodation is not ordinarily employed, convergence tends to suffer from disuse. Its insufficiency, therefore, occurs typically in uncorrected myopes, and it is seen in hypermetropes and presbyopes when their refractive error is corrected for the first time and

also in those suffering from accommodative insufficiency.

6. Lesions in the retinal receptors or in the afferent visual pathways may be a cause of convergence insufficiency.

CONCLUSION

A diversity of opinion exists as to the nature of the convergence insufficiency. A study of the anatomic and physiologic factors involved suggests evidence which seems to justify the contention that convergence insufficiency is an inadequate convergence due to a deficiency in fusional convergence. It is more appropriately called fusional vergence insufficiency and can be diagnosed on the basis of an inadequate fusional convergence amplitude.

Convergence insufficiency may exist as a separate clinical entity unassociated with exophoria or esophoria, or it may exist in association with either. It may also occur with hyperphoria.

Symposium: Convergence Insufficiency

INCIDENCE AND DIAGNOSIS

NANCY M. CAPOBIANCO
NEW YORK, N. Y.

CONVERGENCE insufficiency, as the name denotes, is the inability to converge the eyes properly. In some instances the condition leads to the appearance of subjective symptoms.

This case, as well as the other examples quoted in this presentation, was taken from 67 consecutive cases of convergence insufficiency or suspected convergence insufficiency which were seen by

TABLE I

A FULLY DEVELOPED CASE OF CONVERGENCE INSUFFICIENCY

Name	Age	Sex	Refractive error	N. P. C. in mm.		Deviation in △				Fusional Amplitudes (Synoptophore) in △			
				Obj.	Subj. (red filter)	Prism and Cover Test		Synoptophore		Dist.		Near	
						Dist.	Near	Dist.	Near	Conv.	Div.	Conv.	Div.
RS	19	F	Insignificant	310	810	0	25 BI	0	21 BI	4	8	5	10

In the classic textbook case of convergence insufficiency, the patient has an exophoria which is greater for near than for distance, a remote near point of convergence, decreased or absent prism convergence, especially for near, and normal prism divergence. When all these signs are present, the diagnosis of convergence insufficiency is easily made.

Such a case of convergence insufficiency was that in which a 19-year-old girl presented a large exophoria for near, a remote near point and very deficient fusional amplitudes (table I).

Read at the annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 14, 1952, Chicago, Ill.

me in the private practice of Dr. Hermann M. Burian in Boston. Dr. Burian has permitted me to use some of this material.

Full-fledged cases of convergence insufficiency of varying degrees of severity are not rare, but I do not believe that they are common. As Dr. Fink has pointed out, convergence is a complex process and in many instances certain of the components which make up convergence may be deficient, while other components may be functioning normally. One may find, for example, patients who have a good near point of convergence but poor amplitudes, as in the case of the 19-year-old girl (table II) whose amplitudes were quite deficient, but who had a very good near point.

TABLE II

CONVERGENCE INSUFFICIENCY:
EXOPHORIA FOR NEAR WITH GOOD NEAR POINT OF CONVERGENCE BUT POOR AMPLITUDE

Name	Age	Sex	Refractive error	N. P. C. in mm.		Deviation in △				Fusional Amplitudes (Synoptophore) in △			
						Prism and Cover Test		Synoptophore		Dist.		Near	
				Obj.	Subj. (red filter)	Dist.	Near	Dist.	Near	Conv.	Div.	Conv.	Div.
EM	19	F	M	55	65	0	10 BI	2 BO	10 BI	14	8	10	16

TABLE III

CONVERGENCE INSUFFICIENCY: EXOPHORIA FOR NEAR WITH REMOTE
NEAR POINT OF CONVERGENCE AND GOOD AMPLITUDE

Name	Age	Sex	Refractive error	N. P. C. in mm.		Deviation in △				Fusional Amplitudes (Synoptophore) in △			
						Prism and Cover Test		Synoptophore		Dist.		Near	
				Obj.	Subj. (red filter)	Dist.	Near	Dist.	Near	Conv.	Div.	Conv.	Div.
HS	59	M	H	304	319	4 BI	25 BI	2 BI	15 BI	48	7	40	18

TABLE IV

EXOPHORIA FOR NEAR WITHOUT CONVERGENCE INSUFFICIENCY

Name	Age	Sex	Refractive error	N. P. C. in mm.		Deviation in △				Fusional Amplitudes (Synoptophore) in △			
						Prism and Cover Test		Synoptophore		Dist.		Near	
				Obj.	Subj. (red filter)	Dist.	Near	Dist.	Near	Conv.	Div.	Conv.	Div.
GW	24	F	M	40	40	0	15 BI	10 BO	7 BI	45	14	65	20

The opposite situation is also found, though it is somewhat rare. Table III presents the case of a 59-year-old man who had a large exophoria for near and an extremely remote near point, but whose fusional amplitudes were relatively good.

One may also encounter patients who have a large exophoria for near but who have an excellent near point and very good amplitudes. A 24-year-old female patient (table IV) presented this condition. She was asymptomatic. Such cases cannot be classed as cases of convergence insufficiency and represent apparently a separate entity.

The so-called accommodation effort syndrome, described by Dr. Hill, must also be mentioned here. It is found in patients who show all the signs of convergence insufficiency, but whose symptoms are not relieved but are aggravated by treatment with base out prism exercises. This syndrome is due to convergence insufficiency of relative disuse and exists only in patients who, because of an anomaly of the function of accommodation, actually use excessive accommodation for any visual task. These patients usually show poor divergence amplitudes for near, so that the print blurs if a few diopters of prism base in are placed in front of their eyes.

How then is convergence insufficiency diagnosed? One must not rely for the diagnosis on the presence of any one sign, nor must one expect in each case the presence of all the classical signs. The careful over-all study of the patient, the correlation of his ocular symptoms with the behavior of voluntary, fusional and accommodational convergence will permit a diagnosis and give the indications for the necessary treatment.

Patients may be asymptomatic if they suppress one eye at near or if their occupation is such that they do not use their eyes a great deal in strenuous close work. However, when symptoms are present they are usually rather typical. They include difficulty in focusing or in altering the focus, the inability to follow moving objects (especially bothersome at the movies or in driving a car), headaches, nausea, and blurring of vision.

Though typical, these symptoms are not pathognomonic for convergence insufficiency. They are largely symptoms of eyestrain, or may also be due to an uncorrected refractive error. Therefore, refraction is done in every case and correction of refractive errors may occasionally remove the cause of convergence insufficiency.

Aside from taking the history of the ocular symptoms and determining the refraction, the routine examination consists of the following steps.

Cover Test

This test is used not only to determine the type of latent deviation but also to find out whether suppression is present. The patient may be aware of diplopia when the dominant eye is deviated, before binocular fixation is assumed, and may be unaware of diplopia owing to suppression when the cover is removed from the nondominant eye. This is especially true for near.

Measurement of Deviation By Prism and Cover Test, Maddox Rod Test, Or Maddox Wing Test

It is important in all these tests to dissociate the eyes thoroughly, and the patient must not be allowed to regain fusion while these tests are performed, since it is often noted that a latent deviation which at first appeared to be small, actually proves to be much larger. For this reason also the amount of prism

strength in the prism and cover test should always be increased beyond the point of neutralization of the eye movements; that is, it should be increased until a reversal of the eye movements is noted.

Determination of the Near Point of Convergence

Many authors place little value on the determination of the near point of convergence in the diagnosis of convergence insufficiency for the reason that it often does not correlate well with the fusional amplitudes. This is quite true of the routine measurement of the near point of convergence by which the so-called objective near point is determined. It is less true of the determination of the subjective near point.

In determining the objective near point, an object is brought toward the eyes in the midline of the head and the distance from the eyes up to which they are able to converge on this object is measured. The examiner determines this point by observation. Voluntary convergence plays a large part in the result obtained in this test, as is shown by the fact that a better measurement is often obtained when children are presented with a fixation object that contains detail and arouses their interest.

The cooperation of voluntary convergence is minimized and the absence or presence of suppression is noted when the near point is determined subjectively. This can be done by placing a red filter in front of the patient's dominant eye and using a light as the fixation object. The light is held at such a distance that if the patient is not suppressing, he will fuse the images of the two eyes and will see a "mixed" or "pink" light. The light is then slowly advanced toward the nose, and the place is noted at which the patient loses binocular single vision and reports diplopia. As a rule, the near point determined in this manner is more remote than the objectively measured near point.

The determination of both the objective and subjective near points is of some diagnostic as well as prognostic value. There is, as a rule, a good correlation between the subjective near point and the fusional amplitudes. If the patient has a good objective near point and a remote subjective near point, the fusional amplitudes are usually found to be poor and the patient is likely to complain of symptoms. If both the objective and subjective near points are good in spite of restricted fusional amplitudes, the prognosis is generally good, for such patients tend to respond rapidly to treatment. Also, the subjective near point is a better index of the progress made by the patient than is the objective near point. The latter will often improve quickly, since the patient soon learns the trick of converging his eyes voluntarily. Only the subjective near point gives a true picture of the progress made by the patient, since it improves as the fusional amplitudes improve.

Determination of the Fusional Amplitudes

The fusional amplitudes may be determined at distance and near fixation either with prisms (prism ladder or rotary prism) or with a major amblyoscope. It must be noted that the starting point is different in these two types of tests. In the test with the prisms the starting point is from the parallel position of the eyes; in the test with the major amblyoscope the fusional amplitudes are measured from the patient's angle of deviation. To make the results obtained in the tests comparable, the figures with the prisms must be correlated with the patient's heterophoria. Also, it must be noted that measurements of the deviation with the prism and cover test

and the major amblyoscope may often differ. Patients tend to show more esophoria and less exophoria on the major amblyoscope than with prism and cover test. This is due to the awareness of nearness of the targets on the major amblyoscope even though they may optically be at infinity. This factor must be taken into consideration when reliance is placed on measurement with the major amblyoscope alone.

In both types of test the blur, break, and recovery points of convergence and divergence may be determined. The blur point indicates that the limit is reached of what fusional convergence can achieve and that accommodative convergence is being called into play. The break point occurs when the limit of accommodational (and voluntary) convergence has been reached. The recovery point tells us something about the patient's readiness to fuse disparate images through voluntary convergence and fusional response to disparate stimulation.

The systematic application of these four groups of tests will uncover all cases in which a deficiency of the convergence function may be responsible for the patient's symptoms.

The question of the incidence of convergence insufficiency cannot be answered in terms of absolute or relative numbers, since there are no reliable statistics to permit a definite answer. There is no doubt, however, that it is a frequent occurrence.

No age group is immune to convergence insufficiency. A distribution of the ages of the 67 patients seen in Dr. Burian's office and mentioned before has been made (fig. 1). The ages from 5 to 75 years are pretty evenly represented. The maximum reached between the years of 16 to 30 should probably be attributed to the fact that during this period more exacting visual tasks arise in school and working life. Symptoms are apt to make their first appearance then and the patients seek help.

AGE DISTRIBUTION OF 67 CONSECUTIVE CASES OF CONVERGENCE INSUFFICIENCY

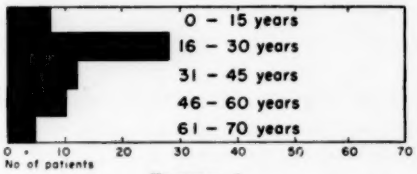

FIGURE 1.

Among the 67 patients, 39 were female and 28 were male patients, indicating a preponderance of females among the patients with convergence insufficiency. This has been noted by other observers, who set the ratio of females to males at about 3:2.

There does not appear to be a significant correlation between refractive error and convergence insufficiency. The distribution of the refractive error in this group of patients shows a normal distribution curve (fig. 2).

DISTRIBUTION OF REFRACTIVE ERRORS AMONG 67 CONSECUTIVE CASES OF CONVERGENCE INSUFFICIENCY

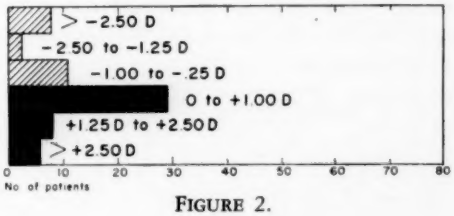

FIGURE 2.

From this study it would seem that convergence insufficiency is a separate entity, a condition in which the convergence function in its various components is independently affected.

Symposium: Convergence Insufficiency

* * *

MEDICAL MANAGEMENT

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THE GREAT frequency with which convergence insufficiency occurs and its disabling symptomatology make it desirable for the ophthalmologist to recognize when it is present and to be prepared to prescribe appropriate treatment.

The criteria upon which a diagnosis of convergence insufficiency may be based have already been presented, but if only the classical cases are given the benefit of exercises, many patients whose convergence power is inadequate and whose symptoms arise therefrom will be denied treatment. There are a great many patients requiring more convergence power or a greater elasticity of convergence than they possess, and a little care will prevent any of them from being overlooked. In addition, therefore, to treating cases presenting the classical signs and symptoms, consideration of the necessity of convergence training should be given in the following four instances:

1. A very poor near point of convergence even with no exophoria at 13 inches. In such cases the exophoria will occur within the 13-inch standard diagnostic distance and will be found to increase sharply as the light is carried closer to the eyes.

2. A low and poorly sustained prism convergence power even with no exophoria at 13 inches. If a single test alone were to be employed in evaluating the capabilities of the binocular mechanism, the prism convergence power would be the preferred test. None of the standard tests reveal the ability of the convergence power to continue to perform for seven to ten hours of close work a day, but a study of the adducting power comes closer to being an acceptable guide than any of the others. This test provides some information on the reserve power which can be employed in continuous near work, but even so, too many factors enter into ocular fatigue to allow its time of onset to be predicted by any test. In all instances, therefore, where the prism convergence power seems inadequate, it will certainly do no harm to carry on some convergence instruction.

3. Inability to get satisfaction from a properly prescribed pair of glasses seems frequently to be due to an unwillingness of the accommodation convergence relationship to reach a new and comfortable adjustment. The greater flexibility of convergence acquired by training will bring about a comfortable adjustment more quickly.

4. The lack of stimulation to convergence when presbyopia is corrected is many times a source of discomfort to patient and physician. In this type of

Read at the annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 14, 1952, Chicago, Ill.

case as in group 3, convergence training is required to bring about a prompt and satisfactory solution to a minor but annoying situation.

When it has been decided that the convergence insufficiency should be treated, no time should be lost in instituting an effective program. The majority of patients with convergence weakness will respond to training without great consideration or examination to determine the cause of the weakness. Two exceptions must be kept in mind: (1) a very poor convergence power in association with a profound neurasthenia, and (2) a very poor convergence power in association with an organic central nervous system disease, notably Parkinson's disease.

In the first instance the patient needs general medical assistance as well as specific attention to the eyes. Encouragement is the keynote to helping this patient, and the convergence training must be kept at a level consistent with the patient's low threshold of effort. Impatience and abruptness will destroy the confidence of the patient and decrease the assistance to be rendered by the physician.

In the second instance the underlying disease may be very easily detected, but it is important to remember that convergence weakness, almost a paralysis, may be the first symptom of the progressive neurologic disorder which is to follow. The true nature of the situation may be revealed only when the response to carefully instructed training is discouraging.

There are some other contributing factors to convergence insufficiency, such as errors of refraction, ill health and fatigue, which should demand consideration before training is started. As already mentioned, however, in the majority of instances the errors of refraction have already been properly taken care of, the general health is good, the patient is not neurotic and does not have any organic nervous disorder, and the only situation requiring help is the convergence weakness. Fortunately it is this kind of case that can be helped so quickly and so inexpensively.

Such considerations as the promptness of the response, the cost of the training to the patient, and the enthusiasm with which the physician can undertake the training have led to the use of loose prism exercises as the standard therapeutic procedure. This kind of exercise almost never fails to bring relief from asthenopia remaining after correction of errors of refraction, and while there may be no gross change in the position of rest of the eyes, the newly developed convergence skill makes the use of the eyes more natural and less fatiguing.

The equipment required for this training is limited to a set of prisms and a candle. The instruction may easily be given by the physician or it may be turned over to an orthoptic technician. Convergence insufficiency probably is present at any age but generally gives rise to first symptoms at an age when prism instruction is very easy to follow. The instruction should never be carelessly or perfunctorily given but rather with sufficient deliberation to be sure it is understood by the patient. A willingness to undertake the exercises will be obtained from the patient by the faith and confidence the instructor has that the treatment will relieve the patient's symptoms. The desire to continue the exercises will be very strong if the instructions are simple and the cost of the exercise well within the patient's ability to afford. All of these conditions are met by loose prism exercises.

It is impossible to go into every detail of the exercise instructions, but the main points of the technic can be very

easily reviewed. The instructions are given to the patient on a typed sheet, but in all cases this data is supplemented by sitting down with the patient and going over each section in detail. The technic as outlined on the instruction sheet is as follows:

1. A prism is a piece of glass which has been cut in a triangular shape with a thick end (base) and a thin end (apex).

2. When doing the exercises the prism is always held so that the thick end is out. Either surface of the prism may be placed in front of the eye, or against glasses if you have been instructed to wear glasses while doing the exercises. The prism must be held absolutely level. Tilting the apex of the prism up or down will give you two images separated in a vertical direction, which you will not be able to get together.

3. A candle should be lighted and used as the object which you are to look at. The exercises are done with the candle at two distances: the far exercise with the candle at 15 to 20 feet and the near exercise with the candle at 2 to 3 feet. The far exercise is done first with the candle placed on a table level with your eyes. You should be seated comfortably in a chair with the box of prisms beside you. [Of course you may prefer to modify the far and the near. You may want to do the near first, and I cannot see that it makes any difference.]

4. The illumination of the room should be dim and it is best if the main source of light is behind your chair. [Frequently patients will ask if the lights should be off, and it is well to have the instruction written on your sheet.]

5. The box which you obtained from the optician contains certain key prisms which you use either separately or in combination until you have developed a convergence reserve of 45 prism diopters. The following steps in the use of the prisms is suggested: begin with 5, then go on to 8, 10, 12, 15, 15 + 3, 20, 20+3, 25 + 5, 20 + 8, 25 + 10, 25 + 12, 25 + 15, 25 + 15 + 3, 25 + 20. [Most of the patients will have a prism convergence power of 5 and yet the majority of them will not have 8. We will ask them then to start with 5 and then quickly go up to 8, 10, and so on until they have reached 25 + 20, which we consider to be an adequate amount.]

6. Choose the prism you have been instructed to begin with and hold it base out before the eye, with both eyes open. When you now look at the candle, you should see two candles. The object of the exercise is to bring the two candles together, then hold them together for a moment, take the prism away and repeat. Do the exercise ten times before one eye, then ten times before the other eye and repeat over and over again. If the two candle lights come together easily, you are ready for the next strength, but if you are having difficulty getting the two candles together it may be better to go back to the next lower one. Blinking your eyes will help in getting the candles together and concentration is always necessary.

7. The exercise should be done for 20 minutes once or twice daily, 10 minutes of far exercise, 10 minutes of near exercise.

8. You should be able to do one or two prisms (probably 5 and 8) at the first exercise period, then begin the near exercise with the highest prism you just finished using at the far distance. [That is an important point. If they are doing the far exercise first, you ask them to begin the near exercise using the highest prism they used in the far exercise. If they have finished off the far with 8, they should begin the near exercise with 8. They will frequently telephone and, in one way or another, request some in-

struction about that. So, we carefully put it on the instruction sheet.] Never begin an exercise period with too strong a prism but also do not waste time on prisms that you can do easily.

9. The entire training period will be about six weeks or three months but may be shortened by regular daily practice.

10. Avoid daydreaming and staring. [This is a pet of mine. I think most patients, when questioned about daydreaming and relaxing their attention, which is really what it is, will be rather resentful about it, but the next time they come back to you, you will be rather surprised, as they will bring the subject up and will frequently say, "I had no idea I daydreamed quite as much as I do." People will daydream, for instance, going to and from work, by looking out the window of a bus or a street car, or even driving their own car, walking down the street, or in their office, they will look out the window and daydream. It is extremely important to call their attention to it and ask them to avoid it.]

The prisms are handled in sets as outlined in the instructions and the financial arrangement can be worked out by the optician. A deposit to cover the cost of the prism set should be asked of the patient, which is refunded when the patient returns the prisms. A small rental per month will reimburse the optical company.

If any point of the technic requires re-emphasis, it is that the exercises must be done regularly and that the patient must not daydream or repeatedly relax his attention. The physician must remind the patient to keep his eyes fixed on objects up close to him and not look far away and allow his attention to wander. Almost every patient with poor convergence power will admit to repeated relaxation of his attention or daydreaming, and recovery of good convergence power will be greatly delayed if attention is not given to overcoming this bad habit.

The exercises should be continued until a convergence power of 45 prism diopters or more has been achieved, when the frequency of the exercises may be reduced. The training period varies a lot but is seldom less than four weeks and may be eight weeks. The prisms are then returned to the optician, although in some instances a patient may wish to buy a few prisms (10, 15, 20, 25) to allow a continuance of the exercises once or twice a week for an indefinite period of time. The convergence power gained through training is well maintained and the relief of symptoms is usually complete. If a relapse occurs at a subsequent time, the prism exercises may be resumed.

Other types of exercises are available for convergence weakness and should be made use of when necessary.

1. The simplest of these exercises is the pin to nose training. A pin with a large colored head is held at half arms' length in front of the eyes and fixed sharply with both eyes. The pin is carried gradually toward the bridge of the nose without allowing either eye to deviate. When the pin doubles, blurs badly, or has reached the bridge of the nose it is carried out again to its original position. Good convergence power will allow the pin to be brought within an inch or two of the nose. The exercises should be done with reading glasses on if they are necessary and may be repeated a great many times each day. Patients are rather fond of mentioning that this type of pin exercise was suggested by so and so at such and such a time, but it is rather rare to find anyone who has, or anyone who will, conscientiously carry out this type of training.

2. Home exercises with the stereoscope and slides are widely used for convergence weakness and are held in very high regard. The most readily available units today are those provided by the Keystone View Company. These units supply a stereoscope and slides in a single box and various charts may be used. The necessary units should be available for outright purchase or rental. If the exercises can be started before any equipment is permanently purchased, and the patient can experience the improvement that is fairly certain to accompany increased convergence power, better public relations will be maintained.

With this type of training as with loose prism exercises, the patient should be given most careful instructions and should be urged to devote fifteen to thirty minutes to the exercises once or twice daily.

3. The third practical exercise for improvement of convergence power is the use of instruments designed strictly for use in the physician's office. This has the serious objection of requiring the patient to visit the office for every treatment. A combination of home exercises with the loose prisms and office training is just about ideal. The office equipment in general use is (1) Rotoscope, (2) Synoptophore, and (3) Troposcope.

The Rotoscope has the great advantage of forcing the patient to use increasing amounts of convergence power to maintain single vision while the targets are moving at increasing speeds through wider arcs. Because of the difficulties incurred in scheduling office training at frequent intervals, the progress is slow and does not begin to compare with the rapid response accompanying the use of loose prisms.

4. Bar reading is an exceedingly interesting and worth-while item of training technic. Not infrequently a patient will ask, "How do I know if I am using both eyes all the time?" So far as I know there is no simpler way to be sure than to have the patient use a single or double prong bar reader. Physicians should be acquainted with the usefulness of this device. For those few patients having convergence insufficiency with a tendency to suppression the bar reader will be found of certain value.

The importance of the correction of errors of refraction has been previously noted. This applies particularly to the adequate correction of myopia. Blurred distance vision is a cause of inattention and there is no greater natural stimulant to proper fusion than good vision. Overcorrection of myopia has been advised as part of a program to stimulate convergence and perhaps might be practiced in a special case. Proper correction of the myopia and convergence training is more sound treatment.

The use of prisms, base in, in the glasses is not to be considered a substitute for convergence exercises. In the very elderly, or in convergence weakness from organic nervous disease, prisms in the glasses will prolong the reading time and add to the reading comfort. Whatever prism is prescribed should be divided equally between the two eyes.

In summary, convergence insufficiency is a very frequent ocular muscle imbalance. It is no doubt true that convergence insufficiency is almost as frequently a cause of asthenopia as errors of refraction. The diagnosis is easy to make, and even when the convergence weakness is not outstanding, improvement in power through exercises will be greatly appreciated by the patient. This paper suggests the routine use of loose prism exercises as the most economical, the most satisfactory and surely as effective as any other of the usually employed medical measures for convergence insufficiency.

Symposium: Convergence Insufficiency

ORTHOPTIC TREATMENT

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THE orthoptic treatment for convergence insufficiency outlined in this paper has been designed to serve two separate groups. First, the orthoptic technician who has time, experience and complete equipment at her disposal; second, the ophthalmologist whose time is at a premium, has no technician or clinical facilities, and has little or no equipment.

OUTLINE FOR TECHNICIANS

When a patient is referred for treatment, two things may be assumed: good refraction and attention to the general health. Specifically, the blood count, the metabolism rate, fatigue and emotional factors should be investigated.

The psychologic approach to each individual's problem is of such vast importance that it may well be termed the key to success, and no better start can be made than by allowing the patient to give a complete resume of his symptoms, encouraged by an attitude of sympathetic understanding and a few leading questions. This is far from being time wasted, as you will have obtained knowledge pertinent to this individual such as occupation, hobbies and reading habits.

An explanation, in which the value of coordination of the two eyes within acceptable limits is made clear and the necessity for reserve strength (prism convergence) is stressed, must be followed by stressing the need for diligence and absolute cooperation in the performance of the required exercises. Caution against overenthusiasm and the development of symptoms from too intensive practice must also be included.

Equipment for Home Work

3 mm. white-headed pin
Kodaloid, or medium red glass
Pencil flashlight

Home Exercises

Due to the variability of response of patients to the teaching of new or disused skills, the use of a white-headed pin as the object of regard interchangeably with that of a red filter is recommended. This is not to imply, however, that these exercises are of equal value.

Inserting a white-headed pin in the end of a pencil, the patient is instructed to use as a starting point that which it is within his ability to fuse. He is then directed to bring the pin toward the bridge of the nose until a breaking point is reached and diplopia recognized, then repeat.

Unfortunately, however, the majority, due to suppression, will reach the breaking point without recognizing diplopia, thereby nullifying the value of this exercise alone. With a red filter held over one eye (preferably the nondominant) and directing attention to a flashlight, fusion, always at a more remote position, may be described as a "pink light" or, not infrequently, an "orange glow." The flashlight is then brought toward the nose until the breaking point is again reached, the patient immediately recog-

Read at the annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 14, 1952, Chicago, Ill.

nizing diplopia (heteronymous). This has the added advantage of helping to break up suppression which is inhibitory to fusional vergence.

In time, as the prism convergence is built up, the objective and subjective measurements will tend to coincide. A near point of convergence of approximately 20 mm. is desired.

Motility exercises in the six cardinal positions should always be included in the latter part of each exercise period. Frequently the disuse of one function allows a compensatory action in other fields so that while the primary aim of treatment is to bring about convergence sufficiency, flexibility in all positions of gaze and the ability to change focus quickly must be considered an integral part of the training.

Three five-minute periods a day are recommended as minimum, but six are to be preferred.

An occasional patient is encountered who, though displaying normal adduction on dextroversion or levoversion and without having any diagnostic signs of organic intracranial disease, seems utterly incapable of converging. For this patient I offer a method, based on the observance of an incident, that for want of a better name I have termed "shock convergence." Without the patient's awareness, a small object is brought forward over his head and down, to almost eyebrow level, at which time he is asked to look at it. This has invariably proved successful on the initial attempt and with very little practice may be transferred to the primary position.

Orthoptic Exercises at Office

Both objective and subjective measurements are made of the near point of convergence and noted. Your encouragement at this time is of great value and will stimulate enthusiasm for further progress. Not infreqently, however, marked diminution of symptoms is reported the first week.

Prism convergence exercises for near are done, using either loose prisms or a prism bar, until an approximate 10 diopters additional to the original base out amplitude (i.e., 6 diopters plus 10) are attained. This is followed by use of the same amount of prism convergence for distance and *repeated* after a short rest period, for near and again for distance. This becomes a learned reflex, and as such, must follow the laws of learning, through repetition.

The patient is then placed at a major amblyoscope, and with a second grade target, a like amplitude should be practiced. With the insertion of -3.00 spheres, marked suppression, which may have been minimal for distance, may now be noted, a frequent occurrence during accommodation. This should be treated in the usual manner, first grade targets (i.e., ball and box) starting with 10 mm. diameter, through 5, 3, and 1 mm. until foveal suppression has been erased. When the patient can converge with steady movement, the "jump exercise" may be introduced, both for home work and on the major amblyoscope. This closely approximates the use of the eyes in casual seeing.

Physiologic diplopia should be taught the first week, bar reading the second, and voluntary convergence attempted the third. Each of these may be considered of equal importance and an absolute requisite to the successful training of cases of convergence insufficiency.

An additional 10 diopters of prism convergence should be attained each week, with a total of not less than 50 diopters, and preferably 60 or 70, by the time the patient is dismissed.

Four to six treatments are usually all that is necessary. Through the process of rendering the patient asymptomatic, accommodation and the ability to change focus quickly will have been greatly improved and stereoscopic vision, frequently lost due to macular or foveal suppres-

sion, regained. Recommendation of continued bar reading is urged, with occasional red glass fusion exercises. The use of an ortho-fusor or stereoscope may be considered an adjunct in treatment rather than an essential part of it.

Age

Age should definitely not be considered a factor in the treatment of convergence insufficiency. As pointed out by Dr. Fink, the reflexes for accommodation and convergence continue to function throughout life, even though the retinal accommodation reflex becomes less efficient with the onset of presbyopia, and in turn, convergence usually becomes more remote.

Consideration should be given to the fact that as the patient grows older, he must gradually give up activities to which he has been accustomed and rely increasingly on reading, sewing or various hobbies. Every opportunity should be offered these patients to read and sew with comfort even though progress may in some instances be slow. The results are infinitely worth while, a fact that may justifiably be considered orthoptics' contribution to geriatrics.

OUTLINE FOR OPHTHALMOLOGISTS

Office Equipment

Package of red Kodaloid (Eastman Kodak)	$ 1.50
White-headed pins (per card)	.10
Pencil flashlight	1.00
Prism bar (recommended because of convenience)	27.00
Total	$29.60

Two additional prism bars recommended for loan

Following refraction and attention to general health, an explanation of convergence insufficiency and instruction in the use of both the pin and red filter for convergence should be given.

Return Visit to Office

Check both the objective and subjective measurements of the near point of convergence. The patient may now be instructed in the use of the prism bar, with a flashlight as the object of regard, both for distance and near. Caution must be observed not to go beyond approximately 10 diopters additional each week. The value here is twofold: overenthusiasm may not produce symptoms and repetition will stabilize the amount gained.

Second Office Visit

Teach physiologic diplopia and bar reading. Have the patient continue exercises at home until outlined treatment has been accomplished, preferably 60 diopters of prism convergence and a near point of convergence of approximately 20 mm.

The use of an ortho-fusor or stereoscope is optional.

Admittedly, this procedure does not have the advantage of the enthusiasm one may expect from a closer and more constant contact, but with understanding and the expenditure of minimum time and expense it may be expected to prove highly satisfactory in the management of this problem.

SUMMARY

In summary, it may be emphasized that the prognosis for treatment in all selected cases of convergence insufficiency is excellent. The outlined orthoptic treatment is in accordance, certainly, with three of the four convergence reflexes, the components of which are tonic, fusional, accommodative and proximal.

The use of a red filter, which is requisite for adequate diagnosis, is also incorporated as the most valuable tool in establishing sufficient convergence and successful function of a re-established skill.

SUMMARY

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CONVERGENCE insufficiency has been recognized as a clinical entity since the inception of scientific ophthalmology. It is a frequent occurrence and one in which orthoptic treatment is particularly successful. In spite of all this there has been no clear-cut answer to the questions as to what essentially constitutes convergence insufficiency, what the criteria for its diagnosis are, and when and how it should be treated.

The opinions on all these matters are divided and the participants in this symposium have labored to contribute to the clarification of these issues and to arouse interest in them in the hope of stimulating thought and discussions on this important subject.

In summarizing the ideas which have been expressed here tonight and in trying to formulate certain general viewpoints which have emerged, I believe that I am not misrepresenting matters in stating the following.

Convergence is a complex process. It has both a voluntary and a number of involuntary components. Convergence insufficiency is the condition in which all or some of these components do not function properly. The patient is either unwilling or unable to converge normally.

In the diagnosis of functional convergence insufficiency — which is the only type of convergence insufficiency considered in this symposium—the various factors which contribute to the total act of convergence must be investigated to obtain a true picture of the patient's condition. But it is also clear that the consensus appears to be that the most important single factor is the behavior of the vergence movements of the eyes, especially at near vision distance.

Consequently, the treatment of convergence insufficiency consists of more than simply teaching the patient the trick of converging voluntarily, as is thought by some. It consists primarily of developing the patient's vergence movements in response to disparate stimulations. This can be done by different means; with prism exercises, stereoscope exercises, or with exercises on major amblyoscopes.

Convergence insufficiency would seem to be an entity to which no age group is immune and which is not dependent upon the refractive errors as such. It is more frequent in women than in men. The subjective symptoms which it produces are largely those of eyestrain. It is often claimed that patients with convergence insufficiency show neurotic traits. While this is a difficult thing to assess, no doubt there is some truth in this claim. Yet one cannot help wondering whether the convergence insufficiency may not itself be the cause of nervous tension and irritation.

However this may be, there is no question that the over-all results in the treatment of convergence insufficiency are highly gratifying and that the efforts of the ophthalmologists and technicians expended in uncovering and treating cases of convergence insufficiency are well worth our while.

Read at the annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 14, 1952, Chicago, Ill.

INTERMITTENT EXOTROPIA: EVALUATION AND THERAPY

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THIS title is chosen because it is descriptive but does not have an etiologic implication. Actually the type of disturbance of ocular motility under discussion is the so-called divergence excess. As Haessler[10] stated, divergence excess is best defined by the descriptive definition of Dunnington's seven points:[8] (1) Marked exophoria for distance, (2) Excessive prism divergence (overcoming base in prisms), (3) Normal prism convergence, (4) Normal near muscle balance, (5) Normal near point of convergence, (6) Normal rotations, (7) Diplopia, if present, comitant to left and right.

About these points there is general agreement but when one discusses the etiology of the condition, there is wide disagreement. Duane[7] and Dunnington[8] believe that divergence is an active process and that there is a center of divergence. The latter, therefore, hypothesizes that in these cases there is an inherent overactivity of the center of divergence. Bielschowsky,[4] although he agrees that divergence is an active process, believes that the etiologic factor in these cases of divergence excess is an anomalous position of rest, more divergent than usual. Posner[15] disagrees with both of these views. On the basis of phylogeny and ontogeny showing a migration of the visual axes from a lateral to a frontal position plus the anatomic and pharmacologic peculiarities of the extraocular muscles resembling striate muscle of lower species and the involuntary muscles of humans, he considers divergence excess as an anomaly of the tonus equilibrium of the ocular muscles in the nature of an atavistic tendency. He does not think it surprising to find an occasional individual in whom two levels of control exist side by side, the one determining the lateral position of the eyes, the other the parallel position. Scobee,[16] on the other hand, feels that divergence is purely passive; that is, the divergent angle of the orbits plus the elasticity of the orbital tissues counterbalances active convergence on a basis similar to a spring scale. He feels that the etiology of intermittent exotropia is on the basis of anatomic hindrances to convergence, such as abnormal insertions, thickening of the intermuscular membrane and check ligaments about the lateral recti.

In the most recent survey of intermittent exotropia Irvine[11] concludes, "Obviously the cause of intermittent exotropia is not known.... I am inclined to agree with those who believe . . . that divergence excess is a reversion to an atavistic type of innervation of the eyes."

The question of whether divergence is an active process with a definite innervation or merely a passive process due to relaxation of convergence has been debated for many years, since neither side has come up with irrefutable proof. I believe that this question will soon be answered by the use of electronic devices to measure and record ac-

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curately the potentials in the extraocular muscles during both convergence and divergence. The experimental setup has been perfected, but so far no results are forthcoming as there is a dearth of human volunteers who will allow the electrodes to be placed in their horizontal recti. No one of these four theories completely explains the various ramifications of this process. If one accepts the hypothesis of an overacting center of divergence that continues to overact until its opponent vergence, convergence, fails via Sherrington's law of reciprocal innervation, the theory of Duane advocated by Dunnington best explains the course of these cases.

In addition to the fact that the existence of a center for divergence is debatable, there are two other objections to this theory. In the first place, the onset is noted most frequently shortly after birth. In Costenbader's series,[6] 292 of 472 cases had their onset under the age of 1 year with only 24 occurring after the age of 5 years. With such an early onset it seems wrong to blame it on a vergence, which is a skilled binocular function that requires time to develop. The first vergence described in babies is convergence, which is only evident after the age of 3 months (Adler[3] and Keiner[12]). In the second place, the evidence for an overactivity of divergence in these cases is based on measurements using the prism cover test and upon the increased ability to overcome base in prisms. The prism cover test disrupts binocular fixation, and thereby fusion, while one neutralizes the deviation with prisms. In a heterotropia where, by definition, fusion is lacking, one merely controls the choice of the fixating eye.

Comparison of measurements of the deviation of the visual axes for distant and near fixation by this test does not provide either an accurate indication of the amplitude of fusional movements or an indication of excessive or insufficient true convergence or divergence impulses. It merely indicates the influence of another factor, accommodative effort (Swan[18]). Excessive prism divergence or the increased ability to overcome base in prisms may be interpreted as measuring the amount of exophoria rather than the function of divergence. Dunnington[8] states that the prism divergence closely approximates the amount of exophoria found by the prism cover test.

The second theory based on the "anomalous position of rest" (Bielschowsky[4]) is excellent as far as it goes. The excessively divergent position of the eyes at birth favors one eye wandering out before the eyes are linked by the development of the binocular reflexes. However, it fails to explain why after surgical correction of the divergent position of rest, the eyes tend to resume their divergent position in many cases. Obviously there must be another or other factors, probably sensorial, to cause this.

The third theory (Posner[15]) that divergence excess is a reversion to an atavistic type of innervation of the eyes is most intriguing and hypothetically sound to explain this knotty problem. However, there are several objections to it. In the first place, the absence of symptoms is listed as one reason for needing an atavistic theory to explain this condition. Costenbader's finding[6] of 60 per cent of his cases complaining of "visual confusion," and the "panoramic asthenopia" while watching moving or brightly illuminated objects in the distance, as cited by Dunnington,[8] certainly gainsay this absence of symptoms. Second, rather than postulating a second or involuntary type of tonus on an atavistic basis when the eyes are divergent, one can explain it as an

adaptation of normal sensorial responses to the changed motor alignment to which Burian[5] has frequently alluded. Third, Posner claims that as this condition is stationary and there is no successful therapy, it represents a second type of vision, whereas this is contrary to our experience and to that of many authorities.

The fourth theory advocated recently by Scobee[16] is that intermittent exotropia is due to anatomic anomalies hindering convergence. He listed five types of these anatomic anomalies and reported 25 cases in which one or more of these anomalies were present. I have seen anomalies similar to the ones that he described, but I have also seen them when resecting a lateral rectus for esotropia, and I have noted their absence when recessing a lateral rectus in exotropia, so I do not feel that they can be the explanation of this type of case, although they may well contribute to some of them.

In the lack of proper understanding of divergence and its anomalies, we have utilized the following working hypothesis which we feel explains not only the etiology of the condition but also its course, especially the therapeutic successes in some cases and the more baffling complete lack of success in others.

In the first place, we assume that these children are born with an "anomalous position of rest" more divergent than normal. This may be an atavistic trait. As the "position of rest" is unattainable during life and varies with each state of consciousness, we prefer the term "position of inattention" (Swan[18]). This is the position the eyes assume when one is oblivious of one's surroundings, as in "daydreaming." That the divergent position of the eyes in these cases is anomalous and not merely due to the elastic pull of the orbital tissues is shown by the fact that the average person's eyes do not assume this divergent position when daydreaming. Of course, there are all degrees of this divergent position. If it is moderate or marked in amount, the average parent notices it soon after birth. The best time to note it is during feeding before the baby retires for the night. If it is small in amount, it may go unnoticed for years until the patient develops asthenopic symptoms. This plus the fact that parents tend to overlook defects in their children may explain the late onset reported in some series (Lee and O'Brien,[14] over 6 years old in 60 per cent; Duane,[7] teens). With the onset of convergence after the age of 3 months, the outward deviation appears less often and less marked, only occurring when the child is very fatigued or daydreaming. The condition may then remain stationary for many years or, at the other extreme, it may progress rapidly. In the latter event, the exotropia for distance becomes constant, a secondary failure of convergence follows, and constant exotropia for distance and near finally supervenes. More usually the deterioration is gradual. In such cases the exotropia for distance is abolished by voluntary or accommodational convergence. For near there is only a small exophoria with a good near point of convergence.

One can only speculate on what factors are operative in causing the rapid progression in some cases, whereas other cases remain stationary for years. Factors that must be considered are (1) amount of the divergent position of inattention; (2) refraction; (3) personality of the child, and (4) status of the fusion apparatus.

The effect of (1) is obvious: the greater the amount of the divergent position the greater the strain on the fusion apparatus. Factor (2), the re-

fraction, is also important. Whereas it is true that the refractive error of cases of divergence excess does not differ in kind from that of the general population, it is also our observation, as noted by Costenbader,[6] that the amount of hyperopia seems to be less than the average expected hyperopia for their age. The less hyperopia or the more myopia a patient has, the less he can call on accommodative convergence to help control the deviation. Factor (3), the personality of the child, also enters the picture but in a less direct manner. It is our clinical impression that the divergence excess cases seem more quiet and prone to daydreaming than the average child, certainly more so than their esotropic contemporaries. The above three factors all contribute positively or negatively to the fourth factor, the strength of the fusion apparatus. What this vague term means is the ability of the individual to overcome diplopia and visual confusion by fusion.

As Julia Lancaster[13] has said, an individual faced by diplopia and confusion due to malalignment of the visual lines has several choices: (1) he can do nothing—merely tolerate it, (2) he can suppress the images coming from the deviating eye, or (3) he can make the necessary motor adjustment to realign the visual axes—motor fusion. As diplopia is something intolerable, few take choice (1). Therefore, we are left with a choice between suppression and fusion. How the individual case reacts to this choice determines to a large extent the course that his divergent deviation will follow. If he is able to resist the easy way out offered by suppression, he will so build up his fusion apparatus that he will be able to enjoy comfortable binocular vision save under conditions of strain on the fusion mechanism, such as prolonged near work or general fatigue.

Two periods when this strain is particularly likely to become manifest are, first, in the late teens-early twenties period when the amount of close work increases and, second, at the onset of presbyopia when the accommodation is no longer adequate for near work. These are aided and abetted by the fact that the passage of time tends to increase a divergent deviation just as it tends to lessen a convergent deviation due to the reduction in the hyperconvergent tone of childhood, the gradual lessening of accommodation and the increased divergence of the orbits due to facial development. Now this suppression is merely an extension of normal suppression, which we utilize daily to avoid physiologic diplopia and to ignore our surroundings while we concentrate on looking at the object of regard. It is a binocular phenomenon in that it only operates during binocular vision, which is an important fact to remember when testing for its presence. When it is present, it occurs whenever the necessity arises, that is, when the visual axes are not properly aligned. In fact, foveal suppression may occur even when the eyes are grossly aligned to allow a small leeway for the principal visual line of the nondominant eye. If the suppression is consistent enough, the patient may develop a secondary retinal correspondence, thus explaining the puzzling finding of normal retinal correspondence when the visual axes are aligned and anomalous retinal correspondence when divergent.

It is not necessary to postulate a second type of neural tone on an atavistic basis to explain this finding. The degree to which the individual case gives way to suppression determines the course of outward deviation. If he gives in completely, then no effort is made to realign the visual axes so that a constant exotropia for distance and near occurs with a remote near point of convergence, as

the stimulus for convergence is lacking save for accommodation. This can explain the cases that change from intermittent exotropia to constant exotropia by the early age of 3 or 4 years. In my experience these children have been nearly emmetropic or myopic, explaining the lack of accommodative bilateral adduction sufficient to help hold the eyes in line.

Once this suppression has become constant and well established, these cases are very refractory to treatment, for although surgery may temporarily improve the position of the eyes, they tend to drift out again. This hardly seems likely to be due to an overactive divergence center, for if divergence is defined as that vergence which tends to align the eyes from a near to a more distant object, I can see no innervational reason for this overactivity of the divergence center as the visual axes are already divergent. I prefer to think that this is due to the fact that the total outward deviation was inadequately corrected surgically, so that even in the immediate postoperative period the deviation was still outward. This may have been due to inaccurate measurement of the preoperative divergence or to an inadequate surgical procedure. Certainly a lengthening operation on the lateral recti would have little effect as there is little convergent innervation to the medial recti, a fact recognized by Dunnington[8] in 1927 and recently stressed by Scobee[17]. Moreover, a resection of the medial recti alone may be insufficient, as the effect of resection is not great and lessens with time.

These cases call for recession of the lateral recti combined either with resection of the medial recti of both eyes at one operation, as recommended by Guibor[9] in cases he classified as anterior internuclear ophthalmoplegia, or with resection on each eye separately at a close interval before the effect of the first operation has been lost, for an outward deviation where the convergence impulse is lacking due to sensory suppression or organic blindness tends to increase with the passage of time. In other words, the inadequate surgical effect leaves the deviation still divergent so that the impulse from the object of regard still falls temporal to the macula of the deviated eye, an area that has been suppressed preoperatively. Thus there is no stimulus for fusion and the deviation can increase, as occurs in some cases of monocular blindness. It is for this reason that most authorities insist on an immediate postoperative overcorrection so that the impulse will fall on a nonsuppressed area of the retina and fusion will thereby be stimulated.

Fortunately this type of case is the rather unusual exception instead of being the rule. The usual case of divergence excess fits well into Dunnington's seven points with the deterioration only progressing so that the exophoria for distance lapses into an exotropia whenever attention wanes. However, with the stimulus of a near object of regard plus the required accommodation, the patient controls the near position well and shows a normal or nearly normal muscle balance. This condition ensues indefinitely unless a secondary convergence insufficiency appears during a period of stress and starts the process towards a constant exotropia. Sensorially, one usually finds a remarkably deep suppression from the fovea out to the retinal limit of the divergent position of inattention for distance, as is shown by the patient's unawareness of when the eye turns out but with only slight to no foveal suppression for near. This suppression for near may increase and spread temporally as convergence insufficiency ensues, establishing a vicious circle, each increasing the other.

It is our opinion that all of these cases require treatment as early as feasible because we feel that they all tend either to progress or, at least, to be a constant impediment to comfortable single binocular vision. In the early cases before the suppression patterns have become established and while the child is too young for orthoptic analysis and treatment, surgery is the only choice. Recession of 4 to 5 millimeters of one or both lateral rectus muscles is performed, usually bilaterally, as such a young child is rarely brought to the oculist unless the deviation is grossly apparent. We take the mother's word about the extent of the measurement, but we also try to catch the child daydreaming, when one eye will wander slowly out until little or no sclera is visible temporally. On formal testing with the child attentive, one can usually find only a small exophoria for distance and orthophoria for near.

Postoperatively, we attempt to combat any residual suppression or tendency to develop suppression by the use of a haploscopic device utilizing polaroid* and television, so that at least one-half hour a day is spent using the eyes binocularly for distance, as this apparatus requires simultaneous macular perception and provides a high incentive to see both sides of the screen at the same time. With older children who have reached the "age of readiness" orthoptically speaking, 5 years and up, we test for suppression preoperatively and treat any suppression found by the technic outlined by Costenbader.[6] However, following Scobee's idea[17] that these children already have mastered voluntary convergence and converge under any visual stress, we avoid stimulating convergence as much as possible, for postoperatively they may continue to overconverge producing an overcorrection more marked for near. Instead, we tend to work at their objective angle and stress divergence, a function at which they are very poor. This training is only given after the parents have agreed to surgery, for we feel that classic orthoptic training utilizing some base out prism device to build up convergence only serves to mask the true condition and cures nothing.

Treatment is continued until suppression is eliminated and the child has constant diplopia at room conditions. The choice of operative procedure is the same as in the early age group except that prism cover test measurements are utilized to determine whether one or both lateral recti should be recessed. If the measurement is under 20 prism diopters for distance, we have done a unilateral procedure but usually find it to be inadequate. This we feel is not the fault of the operative procedure but is rather due to a failure to measure the total position of inattention preoperatively, as the suppression has already been eliminated. We have utilized various means to try to bring out the total divergent position, such as prolonged occlusion, slow and repeated cover tests, having the child sit with his maximal measured deviation corrected by base in prisms set in a trial frame, the use of miotics to eliminate peripheral accommodation on the theory of Abraham,[1,2] and testing at 150 to 200 feet as suggested by White.[19]

Although each of these procedures has increased the measured amount of the deviation in some cases none has worked uniformly, so we are still trying to find the best way to measure the deviation in order to tell whether it is really under 20 prism diopters or whether we have only been able to dissociate them to under 20 prism diopters. The

* Polaroid supplied by American Optical Company, Southbridge, Mass. Apparatus made by Clairmont-Nichols, Inc., Opticians, 16 East 53rd Street, New York 22, N. Y.

reason for all of this stress on the preoperative measurements is that occasionally a bilateral recession produces an overcorrection that persists until corrected by further surgery for esotropia, a condition deplored by parents and surgeon alike. Postoperatively we give intensive antisuppression and fusion training in the orthoptic laboratory along with supervised home exercises, followed by the television-polaroid device.

As stated before, once a secondary convergence insufficiency has developed, the choice of surgery includes a shortening procedure on the medial recti plus emphasis on convergence training orthoptically.

In conclusion, we feel that divergence excess is primarily due to a divergent position of inattention at birth, with its progression due to the development of suppression that can lead to constant exotropia by inducing a secondary convergence insufficiency. The treatment is purely surgical before suppression is established, but after that has ensued, then antisuppression measures, followed at the opportune time by surgery with postoperative antisuppression and fusion training until the result is established, are indicated.

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HOW TO MAKE YOUR OWN ORTHOPTIC SLIDES

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THE ABILITY to make your own orthoptic slides or stereoscopic cards can be a source of satisfaction because you may add greater variety to your collection of commercial slides and because you may help the doctors with whom you work to prepare slides based upon new principles. Others have reported their experiences with slides of specific design and character, both as to functional results obtained and the ease with which patient interest and cooperation is elicited. Any discussion on the production of original slides should not, by any implication or suggestion, put limits upon the subject matter or character of targets which might be used. If this latter aspect is discussed at all, it should be done in such a way as to leave the orthoptist free to judge the writer's findings and to proceed with further improvements in a creative manner. Our present subject limits us to suggestions regarding the mechanics of slide making.

Many such slides can be produced without outside help merely by collecting a few materials and special instruments. For others, the services of a photographer may be helpful or even necessary. A very few might require the skill of a professional artist; but some suitable drawings can be had by searching through newspapers, magazines, or other printed matter and simply clipping, tracing, or photographing them.

No matter what the source of the subjects for slides, there are certain common materials which should be available in the office so that slides may be put together quickly and easily. Each slide is made up of two pieces of thin glass, each slightly less than 3¼ x 4 inches. The objects or targets are placed between the two glasses for protection, and these are then bound together by a strip of slide binding tape. Both the glass, which is that used for large lantern slides, and the tape are available through any photographic supply shop. A razor blade or pair of scissors is all that is needed in the way of tools for this binding job.

Any of a number of materials may be used between the cover glasses of the slide for supporting the targets. Cut-out figures or silhouettes can be fastened directly to the glass with rubber cement. Since these will be held partially by pressure of the glass, a touch of cement from a toothpick will be all that is needed to hold them. A photographer can supply you with a black and white transparent picture permanently imprinted on the emulsion of a lantern slide plate so that all you need do is cover this with one glass and bind. Onion skin typing paper or draftman's tracing paper may be used for drawings in pencil, pen or color, and after being cut to size, mounted between glass. A translucent plastic film called traceline, available through drafting supply houses, may be used instead of thin paper. A small supply of red, green, blue, and yellow cellophane may be of use for large cut-out areas of color. Opaque black paper should be available for cutting silhouettes, making frame-

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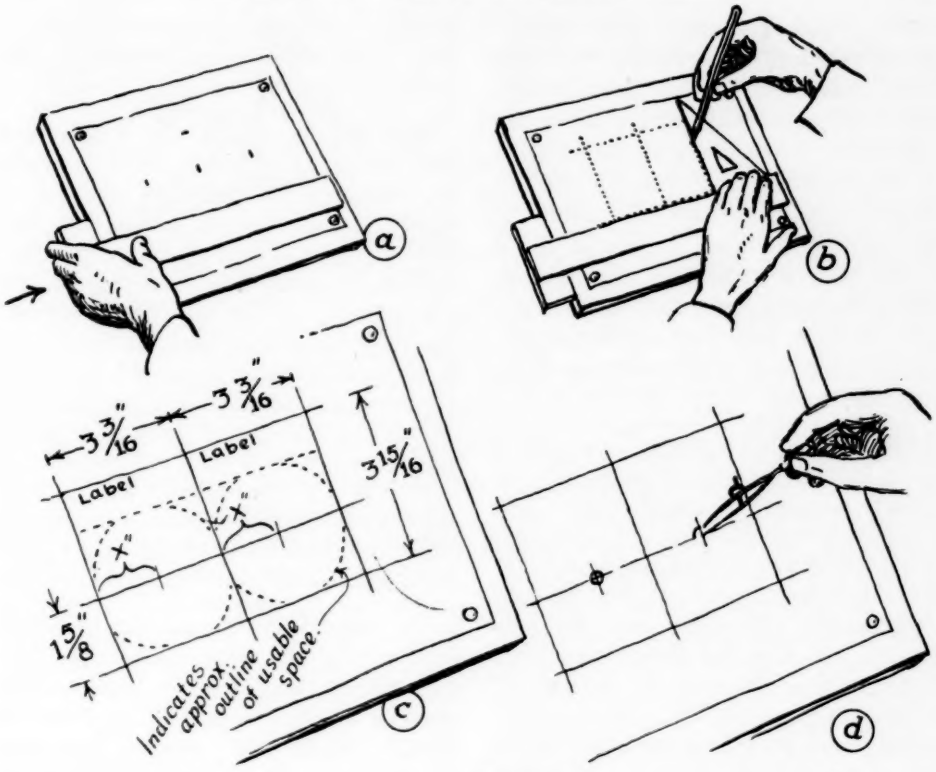

FIGURE 1.

like mats, etc. Scotch tape can be used to hold objects in the slide either temporarily or permanently.

The most important factor in making a satisfactory slide is accuracy in spacing and aligning the visual objects of any pair so that they will be projected in exactly their intended positions on the retinas of the eyes for any given setting of the major amblyoscope. This cannot be overemphasized, especially in regard to macular targets. For slides where original drawings are done on thin paper or film, it is advisable to use a few simple drafting tools. If any of you have made slides by tracing the outline of the glass cover on paper and placing the targets within this space, you know how many errors can slip into the work, even with much checking and rechecking of measurements. One trial of the drafting board method will prove its advantages in speed as well as accuracy.

Many book stores, drafting supply or art supply stores sell for about $2.00 small kits which contain a drafting board about 10 x 12 inches, a T-square and two small triangles. You can also buy separate compasses, dividers and ruling pens. Thumb tacks, art gum, India ink, and an HB pencil complete the outfit needed.

Instructions in making a simple pair of foveal slides must suffice here to outline the fundamental procedure and suggest possibilities for further work.

Thumb-tack a sheet of onion skin paper lengthwise across the drawing board, as shown in figure 1a, and measure off, horizontally, two spaces, each 3 3/16 inches wide. Then measure vertically a space 3 15/16 inches high.

Holding the T-square head firmly against the left edge of the drawing board, draw a horizontal line through each of the latter points by following the upper edge of the T-square beam with the pencil. Then, still keeping the T-square firmly in position, place the triangle against the beam as seen in figure 1b, and draw vertical lines, through the points first measured off. You will now have outlined two vertical rectangles, each of which represents the total area of a slide.

Only a roughly circular area about 3 3/16 inches in diameter at the bottom of each rectangle is usable space (the top ¾ inch may be used for labeling), shown schematically in figure 1c. Therefore, the visual object can best be centered about 1 ⅝ inches above the bottom line. Measure this distance up from the bottom and draw a faint horizontal line at that level with the aid of the T-square. Next, locate the horizontal position of the objects. It is not essential that they be exactly in the middle of the slide, but if one is displaced to the left in one slide, the corresponding point on the other slide must be displaced exactly the same amount to the left. Therefore, with any convenient means at hand, measure from, say, the left hand margin of one rectangle and mark a point very near the center; then mark off the same measurement from the left hand margin of the other rectangle. You are now ready to draw the visual targets centered on these points.

Foveal targets should not be larger than 3 mm. in diameter; so, to delimit the area, draw a circle of that size on each rectangle after carefully centering the compass, as in figure 1d, upon the points just determined. If the targets in this slide are to be a cross presented to one eye and a circle to the other, proceed to draw the cross with the ruling pen and India ink, utilizing the T-square and triangle for perfect verticals and horizontals, and the pen compass for the circle.

It should be pointed out at this time that any line has width. Therefore, the ink compass must not be opened so widely that the center of the ink line falls over the 3 mm. diameter penciled margin. Instead, the outside edge of the line should coincide with the center of the original pencil line. Neither must the ends of the cross extend beyond the center of the penciled circle. (This relationship of width of line and edge of area must be kept in mind constantly, especially if areas outlined with ink are to be filled in solidly. Areas in a pair of slides are likely to overlap where this is undesirable, if care is not exercised.)

Put identifying marks on the slides and indicate the front surfaces so they will always be faced correctly. After erasing all pencil lines, the rectangles may be cut out with scissors. Care must be taken to cut a straight, even outline. It is really best to cut along a straight edge with a razor blade. Follow the bottom edge especially carefully. Lay one of the rectangles on a clean piece of glass and cover with a second glass. Stand this "sandwich" up on the bottom edge on a flat surface, separate the cover glasses so the paper must drop all the way down, as shown in figure 2. Close the cover glasses and hold firmly together while binding them in this position with a couple of small pieces of scotch tape. Bind the other of the pair in the same way.

If the edges of the two slides are exactly superimposed and they are illuminated from behind by a good light, the cross will appear exactly centered within the circle. If they are not centered on one another, one or both the slides must be unbound and the paper moved to the proper position. Both slides may be placed, one behind the other, in the

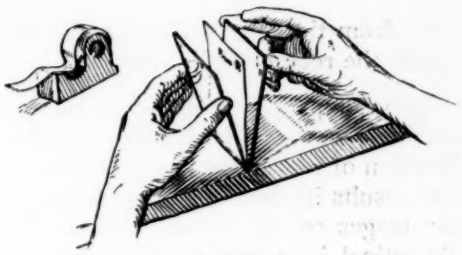

FIGURE 2.

same arm of a troposcope for superimposition. This is, by far, the best way. When the spacing is correct, run binding tape around the edge.

The most accurate foveal slides may be prepared by first doing drawings two or more times larger than desired, then having a photographer reduce the drawings to the desired size. He may reproduce black and white drawings on regular film or colored drawings on color film. Errors in drawing can be kept proportionately small in such oversize drawings, and the standard photographic procedures may further smooth out minor irregularities.

The same accuracy should be carried through with all macular and peripheral slides because this gives the necessarily reliable foundation for all work done with them. It is even conceivable that care should be taken with the outside borders of peripheral slides to prevent irregularity of framing from influencing other features.

If the clear areas of a slide are quite large, it is best to insert a sheet of very thin white paper or a piece of traceline in the slide behind the object to reduce the total intensity of the illumination. This will aid in accurate localization of the catoptric images and make the light more comfortable for the patient. Where the transparent areas are small, it may be advisable to leave out any such diffusion films so that the catoptric images will be bright enough to be seen.

A brief discussion of stereoscopic slides might upon first thought seem adequate here. However, since the technics of producing simple stereograms are not widely known, and since there is a chance you might wish to try your hand at some of this fascinating work, we will take this opportunity to give you a little basic information.

Simple stereoscopic slides are not more difficult to make than those already mentioned. Here, the accuracy required in placing the various elements is no greater than that for foveal slides. Of course, complex stereoscopic slides may require special treatment, and many which are intended for taking fine measurements must be calculated mathematically and drawn with precision. On the other hand, those slides which you might wish to make to add variety to your collection of gross stereoscopic targets may be done by applying simple rules based upon your understanding of stereoscopic principles. Such procedure involves an intuitive approach as contrasted with the mathematical.

You all know that it is not necessary to have objects actually spaced at different distances from the observer in order to activate the mechanisms of his depth perception. A controlled horizontal disparity of like images on the retina is all that is required, and the object source of these images may be placed at any distance from the eyes so long as the visual fields of the two eyes are isolated from each other.

This is done in the case of stereoscopic slides or cards with two similar, but unlike, two-dimensional representations of stereoscopic subjects. At this point we encounter a confusion of terms which we must understand before going further. The representations on the two-dimensional surfaces are *images* of a three-dimensional *object*. They may be created by a camera or by setting up

two sheets of transparent material side by side in front of the object and tracing its outline or point relationships. Others may be created by mechanical drawing or by freehand drawings. But when we view these *images,* they become the *objects,* and the optical system of the eye projects *images* of them on the retinas. For all intents and purposes, this latter object presents to the retina an image identical to that of the original object. In other words, in a stereogram we have, or conceive of, an object of which we make pictures; then these pictures merely substitute in the stereoscope for the original object.

Following this reasoning further, if one picture object in the stereogram has all the dimensional characteristics of the first or original object seen from one point, and the other picture as if it is seen from a point a few centimeters to one side to correspond to the separation of the eyes, and each picture is presented to the appropriate eye, the observer is furnished with all the true stereoscopic relationships he would have from viewing the original object directly.

Knowing these facts, you can now place two points upon each of two sheets of paper and position them in the observer's consciousness of space relationships just as effectively as if you were to walk out in a real depth situation and move a real object to a predetermined position.

What happens to the two retinal images when an observer fixates a point object (a) in space and another point object (b) is moved toward him? The image of (b) moves temporally in one or both eyes, as diagrammed in figure 3. If point (b) starts from a relatively peripheral position, the image on one retina might move nasally, but the summation of movement in both eyes is still temporal. Of course, moving the object away from the observer moves the image on the retina nasally.

To accomplish a comparable result by drawing, we must next consider what direction of movement in the field of vision results in the proper movement of the images on the retina. If you wish the retinal image to move temporally, the object must move toward the nasal field, as noted on figure 3, and for the image to move nasally on the retina, the object must move toward the temporal field.

It is not necessary to remember consciously any of the foregoing while doing a stereoscopic drawing. Instead you should fix the following simple rules well in mind.

If you have drawn two point objects in a stereogram and you wish to move one of the objects nearer the observer, move the point to the right in the drawing for the left eye, and to the left in the drawing for the right eye. If you wish to move the object farther from the observer, move the point to the left in the drawing for the left eye, and to the right in the drawing for the right eye.

Since it may sometimes be desirable to relate the displacement of the objects to the prism diopters of convergence or divergence required of the eyes, the following figures may be helpful: In the synoptoscope, *assuming that the arms are held in fixed position,* convergence or divergence of 1Δ requires a displacement of the image on one side of 1.54 mm. This is based upon Prentice's rule that centimeter displacement of the object multiplied by dioptric power of the viewing lens is equal to diopters of vergence. We may state, then, that the diopters of vergence divided by the dioptric power of the lens equals the required displacement of the object on the slide. Since the power of the synoptoscope lens is given as 6.50, $\frac{1}{6.50} = 0.154$ cm. or; 1.54 mm. displacement = 1Δ of vergence.

If we wish to move the objects on both slides, this figure of 1.54 mm. must be divided between them.

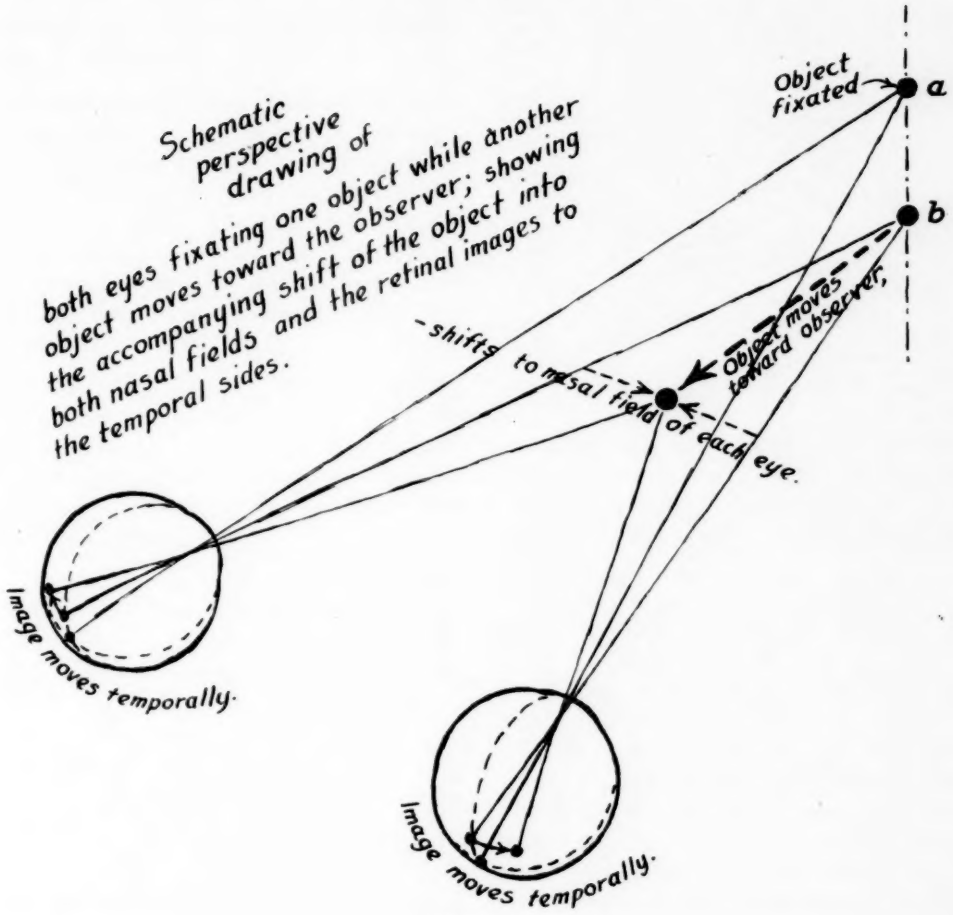
Schematic perspective drawing of both eyes fixating one object while another object moves toward the observer; showing the accompanying shift of the object into both nasal fields and the retinal images to the temporal sides.
Object fixated
a
b
shifts to nasal field of each eye.
Object moves toward observer,
Image moves temporally.
Image moves temporally.

FIGURE 3.

For the troposcope with its 5.0 diopter lens, 2 mm. displacement of the object equals 1Δ of vergence.

A simple demonstration of the use of the rules may be given by laying out two slide-sized rectangles on a sheet of onion skin paper, as described for the foveal slides. Next, draw lightly three horizontal lines, as shown in figure 4a, about ¼ inch apart, near the center of the usable areas of the spaces. Mark the horizontal center of each rectangle with a faint vertical line. Where these lines intersect the top horizontal line, make an ink dot about the size of a pinhead. The dot on the left hand rectangle will be seen with the left eye, and the one on the right with the right eye when the finished slides are placed in the major amblyoscope. Thinking ahead, you will know that the dots will be superimposed and fused, and if all settings of the amblyoscope are at "0," the dot will appear at infinity.

Consider that you would like to place dots on the middle horizontal line so that the final fused object will appear nearer than that on the top line. Following the stated rule, place an ink dot in the left rectangle about 1/16 inch to the right of the vertical line and one in the right rectangle the same distance to the

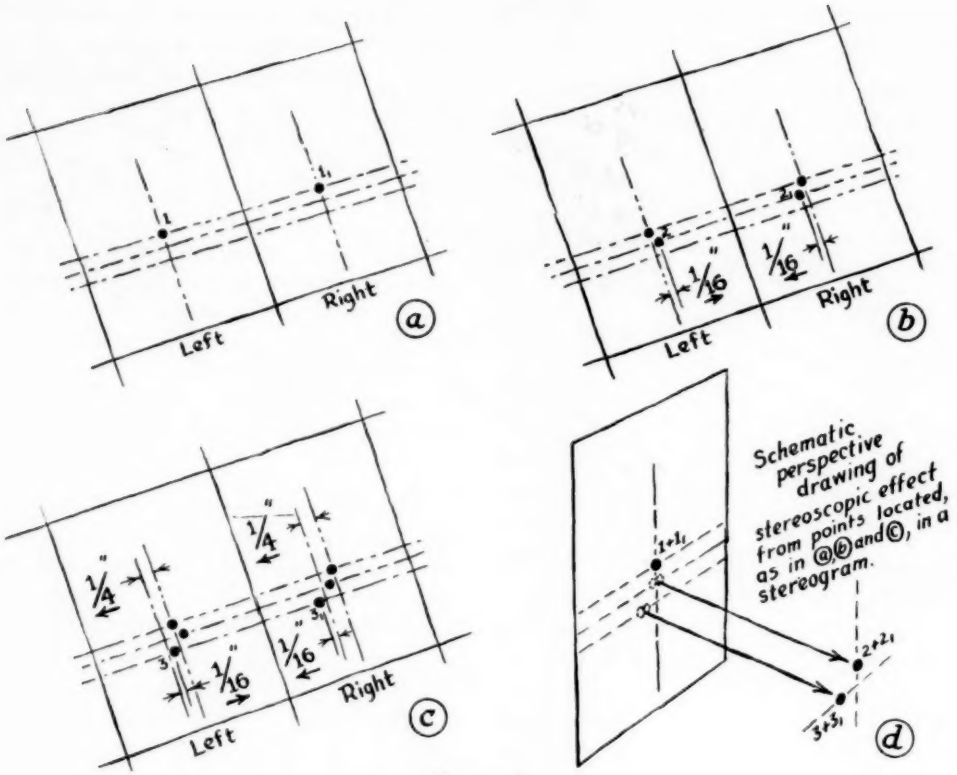

FIGURE 4.

left of the vertical line, as in figure 4b. When this is fused in the finished slide, it must appear as intended.

Further, to prove the dependability of the rule, by a variation in its application, plan to place a third point on the bottom line, which will be at the same distance as the second one but displaced to the left of the original visual line. To do this, measure ¼ inch to the left of each vertical reference line and make a pencil mark, as in figure 4c. This is in effect a new point of reference which would appear at infinity if viewed. Place an ink dot 1/16 inch to the right of the pencil mark in the left rectangle, and one dot 1/16 inch to the left of the mark in the right rectangle. Leave the pencil lines or erase, as you choose; cut out the rectangles and mount in glass. When seen in the major amblyoscope, the ink dots will relate both in depth and lateral displacement as intended. The spatial relationships are shown in perspective in figure 4d.

Except for special cases, the farthest object in any stereogram should be placed so that the eyes do not diverge when the viewing instrument is set at "0." Therefore, if the first object drawn is intended to appear close to the observer, it must be placed somewhere to the right of the center of the left slide and to the left of center in the right hand slide, as indicated in figure 5. The last half of the stated rule can then be applied in locating more distant points. The practical limit is reached when the most distant point is placed in the horizontal center of the slide or its equiv-

alent in either the right or left field relative to the center.

If you should become ambitious with complex stereoscopic forms of any sort, you must keep in mind that no vertical displacement must be allowed between points representing identical points on an object. This can be controlled by always using the T-square to check that such points are the same height on the two slides, as in figure 6.

As a general rule, objects requiring long attention should not be placed so far nasally on the slides that prolonged convergence becomes uncomfortable, unless such prolonged convergence is expressly desired.

You may purchase View Master stereoscopic disks or Tru-View stereoscopic strips, cut out the stereoscopic pairs and mount them between glass by

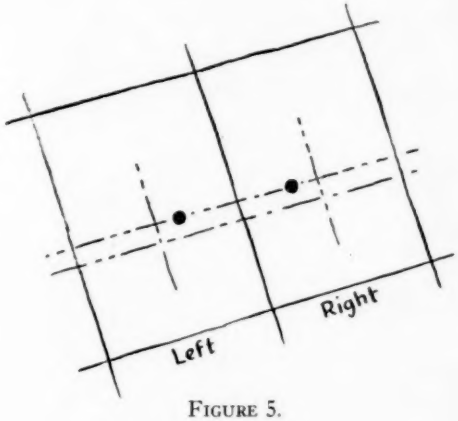

FIGURE 5.

taping them directly to the glass or first mounting them in black paper mats. Other already prepared stereoscopic material may be used in a similar manner, either on major amblyoscope slides or stereoscope cards.

Standard stereoscope cards are usually opaque rather than transparent like major amblyoscope slides. Therefore, targets or pictures may be presented

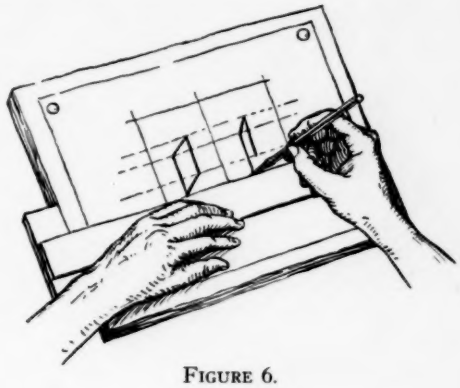

FIGURE 6.

upon heavy cardboard 3½ x 7 inches. They may be directly on the cardboard or may be from a separate paper cemented to the board. A good grade of artist's illustration board is ideal in either case, but in an emergency poster board will serve. Rubber cement is good for mounting separate sheets to these boards. Finished cards may be soil-proofed by spraying the surface with Krylon, an acrylic type lacquer spray, available at many paint, art goods, or drafting supply stores. (Krylon spray will allow some colored pencils to run badly, so a test should be made on a separate paper before coating.)

The same points of accuracy must be observed for stereoscope cards as for slides. Here, however, the problem is somewhat reduced by having the objects for each eye mounted together, where careful alignment can be visualized readily.

Where targets are to be drawn directly on the card, it may be thumb-tacked to the drafting board. First lay the card near the middle of the drafting board, then place the T-square in the proper position as described earlier. Sliding the T-square head up along the edge of the board, bring the beam upward against the bottom edge of the card. When the entire edge of the card is in contact, place a thumb-tack just outside each up-

per corner of the card so that, when pressed down, they will pinch the corners hard against the board. The T-square may now be laid over the face of the card for positioning and drawing the targets.

Separation between the targets for the two eyes, with the visual axes parallel, is 8.5 cm., and this may be used as a basic dimension upon which to calculate vergences, etc. Following Prentice's rule, as we did in calculating vergences for major amblyoscope slides, it may be said that here, with a 5.0 diopter lens, a total of 2 mm. displacement corresponds to 1△ of vergence.

It is always helpful to lay out the 8.5 cm. separation by first measuring to the center of the card, then marking the points 4.25 cm. on each side. If convergence is desired, displacement of either or both targets will be toward the center of the card, and for divergence, the shift will be toward the edges of the card. Objects may be drawn with any medium suitable for working on illustration board. A list of these would include pencil, colored pencil, pen and ink, water color, and crayon. Generally, it is wise to use a medium which masks the paper texture most, or at least does not accent it.

Be sure, by constant use of the T-square, to keep all corresponding points the same height on the card.

If cut-out figures are to be pasted upon the card, their desired positions should be located in the manner described for drawing direct, and a penciled outline of the shapes checked for accuracy before cementing the pieces in place.

As in the case of amblyoscope slides, photographs may be used. Also stereoscopic figures may be done in the same manner.

Preparation of your own slides, following the suggestions outlined here, can be fascinating work, and it is hoped that you will try the methods and be encouraged by the results to make the slides you keep wishing you had.

SOME BASIC CONSIDERATIONS IN THE MAKING OF SLIDES FOR USE IN THE TROPOSCOPE

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THE ULTIMATE purpose of any slide is to obtain a positive response from the patient. The patient must derive satisfaction from this response; the technician must be able to check its accuracy. This necessitates interest and more than momentary attention on the patient's part. It involves certain technical factors in the slide itself which make objective checking possible. Generally speaking, in making slides our primary aim should be interest, attention and objectivity.

There are certain psychologic factors which promote interest and attention.

1. Primary among these is central spacing of a single object of attention. A young child, especially, is distracted if he has too much to look at. It is better for the technician to suggest action or a story for one central figure than to try to introduce these details into the slide itself. For instance, I once made a slide depicting Mother Hubbard, her dog and cupboard which proved to be completely ineffective as there was no span of attention on any one of the three elements to the exclusion of the other two. As a result, there was no maintenance of fixation on the central figure of the target.

2. When the central figure is in motion, such as a child running, or a dog sitting up to beg, the slide itself suggests action, which creates interest. Many times action must be implied. The active imagination of the young child is in our favor here. He will watch for a door to open, or even for a teakettle to boil.

3. A third factor is simplicity of design. In addition to the fact that our young patient may have sufficient visual disability to prevent him from distinguishing small detail, he is not interested in it. He has not yet learned to comprehend more than what is essential to complete the main concept of the picture. A simple object in bold outline will be more effective than one containing costume detail, for instance. In line with this is the fact that the control marks need to have a direct bearing on the total meaning of the slide. The loss of a control mark should detract enough from the total picture meaning for the child to be aware immediately of its absence.

4. The subject of the slide must be familiar to the child's experience and should be reasonably true to life. Animals should be realistic in color and familiar to the child. Objects which resemble their favorite toys are useful. Reproductions of illustrations in books with which they are familiar are excellent when they can be reduced in size and simplified in design. Kindergarten test forms have a variety of small figures which make excellent slide material because they are simple in design.

5. Color is another attention factor. Bright colors are physiologically stimulating. Further, the young child is apt to be familiar only with the brightest primary colors—blue, red, green, and yellow. Soft shades are generally ineffective as far as stimulating interest is concerned. They may be useful to relax accommodation.

To create an effective slide, one must consider certain technical factors:

1. Size of the fusion elements should be considered. Slides generally are desig-

nated as foveal, macular, or peripheral according to the area of the retina which they stimulate. Obviously, the size of the target determines the amount of retinal area stimulated. When speaking of second grade slides, the size of the fusion elements themselves determines the classification of the slide as follows: (a) foveal, if the fusion elements are 3 mm. or less; (b) macular, if the fusion elements are from 4 to 10 mm., and (c) peripheral, if the fusion elements are over 10 mm. (usually 25 to 40 mm.). A fusion element larger than 40 mm., especially in the horizontal dimension, is usually impractical.

Some add a classification of paramacular for slides in the size range between macular and peripheral targets. I do not find a sharp line of demarcation between paramacular and peripheral in the slides produced to date. It seems to me that the importance of inclusion of this classification for diagnosis would depend on the methods and terminology of the individual technician. For therapeutic purposes, a reasonable size difference between macular and peripheral targets should suffice to differentiate the two clearly.

2. Size and spacing of control marks are of importance. My personal opinion is that control marks should not exceed the fusion elements in size. Control marks have a tendency to move apart before the fusion elements separate on vergences, and this movement on a large scale distracts the patient and lessens the hold of the fusion elements. I prefer a control mark considerably smaller than the fusion element. It is impossible, of course, to get much size difference in foveal targets where the fusion element itself is no more than 3 mm. Ten to 15 mm. would seem to be as large a control mark as is necessary even for use in peripheral areas.

Presumably the same size demarcation holds true for control marks as for fusion elements. In actual use, however, except for foveal control marks which must not exceed 3 mm., we are apt to designate the marks by their position rather than by their size. Two millimeter marks should be within a 5 mm. central area; 3 mm. marks can be effective as much as 15 mm. apart, as in the "clown slide" in the Orthoptic Award Series. Five to 10 mm. marks are satisfactory when separated by 25 mm., which places them in a peripheral area.

The small size of foveal control marks precludes their use in peripheral areas. They must be centrally spaced to be seen simultaneously with clarity. To my mind, the presence and proximity of foveal markings are the crux of an effective slide irrespective of its total size. The closer the control marks are to each other, the less eye movement is involved and the easier it is to observe and check the patient's responses, giving the slide a greater objective value. Its therapeutic value is enhanced as it is directed at the deep and resistant suppression in the central area which must be eliminated if normal binocularity is to be developed.

Even when our main object is diagnosis or development of peripheral fusion, a slide which includes both foveal and peripheral control marks can be used. Peripheral marks should be within the child's perceptive range as he fixes on the center of the target. He may not be able to see them clearly, but he must be capable of awareness of their presence or absence without looking directly at them. The farther separated they are, the more blurred they will be and the greater will be the temptation to shift fixation from one to the other. With this shift in fixation, it is impossible for the technician to check accurately on suppression.

There is some difference of opinion as to the value of vertically spaced con-

trol marks over horizontal and vice versa. My feeling is that the value depends upon the use to which the slide is put and upon the particular condition which we are treating. Vertical check marks may be more easily distinguished than horizontal marks where suppression is intense since the suppression area is more apt to be in the horizontal meridian. On the other hand, vertical marks show more lateral movement on vergences and are perhaps less effective in slides used to increase fusional amplitudes.

I do not believe there is any actual advantage to having control marks within rather than outside the fusional element. Any feeling that this may be true could be due to the fact that the control marks within the central figure are apt to be small and close together while those outside are peripherally placed and usually somewhat larger, thus allowing a greater suppression area and making the slide less effective on that score.

3. The balancing of check marks as to size, position and importance to the total meaning of the slide is another consideration. Those of us who are not original artists and who have to depend on a figure to trace are hard-put at times to find suitable parts of our material to reproduce as control marks. Eyes in a face, ears, an object of similar size in each hand of a figure, a row of buttons down the front of a figure, and windows in a building are easily balanced in all respects.

In treating monocular cases, it is often advantageous to have a set of slides with control marks on one slide predominating over the other in size, importance, and displacement (especially vertical) from the target center, using this slide before the amblyopic or suppressing eye since it has greater stimulus to vision.

4. The use of color in the fusion element as a control is possible but is apt to be unwise for the amateur slidemaker. Color seems to introduce the element of retinal rivalry when used as a central control. Presumably, the intensity of the colors to be blended and the size of the fusion element are factors in the amount of retinal rivalry produced. It is frequently difficult for the patient to report a true sensation of blend or to give a satisfactory fusion response, and we have one less check on the patient's eye behavior.

5. One absolute essential for objectivity in a slide is a central marking of 2 mm. or less on each slide for accurate measurement and as a check on foveal fixation. On checking for fixation, the usually deviated eye may move outward to fix on this small mark in spite of apparently reliable fusional response. Frequently the amount of inward deviation has been too small to observe by position of reflexes; it may not show if the fixation point is of more than foveal size.

Obviously no one slide can contain all the considerations covered so far. Each individual slide has some definite diagnostic or therapeutic purpose—to make manifest or to treat some specific disability. We should keep in mind how the specific disability manifests itself and select those particular psychologic and technical factors which will most effectively diagnose or treat that disability.

It might be well to discuss slides according to diagnostic and treatment categories, selecting some of the factors most important to each.

Amblyopia. I do not use the troposcope to any extent for diagnosis or treatment of amblyopia. It can serve as a check on the acuity obtained on the ordinary vision chart if the size of slide detail (which may be print) is correlat-

ed with the point size of letters as listed on the Lebensohn Test Chart. By relating the size of slide detail with the child's vision, we can select slides to which he can give a positive response.

Anomalous retinal correspondence. The main consideration is the size of first grade targets to be used, especially of the target before the eye we wish to fix. The establishment of normal retinal correspondence is the establishment of a macula-to-macula relationship so that the use of macular size targets (5 to 10 mm.) is obvious. I have found that macular targets work most successfully. In treating alternators, I have often found it necessary in early stages of training to use a larger target for the nonfixing eye in conjunction with a macular fixation target.

Peripheral targets are so large that if superposition is claimed, it is difficult to tell whether it is truly bimacular or a macula-to-nose relationship. Foveal targets, on the other hand, are so small that the suppression usually present in an untreated case prevents bifoveal superposition. The absence of a response of superposition in such an instance could lead to improper diagnosis of correspondence.

Instability of binocular fixation. If we consider the various subjective responses obtained when the patient is unable to report first degree fusion, we can better plan a slide to eliminate these errors. The most common responses are (1) only one image seen, (2) images crossed, (3) images jump from one side to the other, (4) images fluctuate vertically (one goes over or under the other), (5) images only partially superimposed, (6) alternate fading of parts of images (usually of central portion or of contiguous parts).

As implied above, we are considering first grade targets. Fundamentally we want to obtain steady fixation of both eyes, but almost invariably one eye is less steady than the other. Our problem is to create a slide for this eye that will stimulate maximum attention and concentrated gaze. The child's response almost invariably indicates movement of this image. His interest is increased if movement is appropriate to the subject matter of the slide; e.g., a top will seem to spin, a ball will bounce, a bird will fly in and out of his nest. In the Award Series, the cannibal slide is very effective since the cannibal seems to do a war dance. A flower-pot jumping around on a window sill, for instance, is not appropriate and hence less interesting.

I like a fixation target that "fits into" the target before the nonfixing eye. More steadiness seems to be gained than when targets are in vertical juxtaposition.

Another factor which can be used by the technician to good advantage is a fixation image divisible into parts to stimulate the patient to get more and more of the target to fit into its component slide. "The Star and Circle" (Orthoptic Award Series), for instance, works well. The patient gets one point in the circle at first, then two points, and so on, until the whole star is centered.

As in the treatment of anomalous retinal correspondence, peripheral targets seem too large for accuracy and are certainly too large for the desired result. I would set a 15 mm. limit on target size, reducing to foveal slides as rapidly as the patient can progress.

Suppression. Since we must continually attack suppression, all second grade slides need to have antisuppression factors incorporated into them. Especially important are foveal control marks centrally spaced and in close proximity, since suppression is most obstinate in the foveal area.

The patient's response when second grade fusion is lacking may be one of the following: he may see one image with one control mark, the other image being suppressed completely; some areas may blank out; control marks may be out of position without doubling of the image; he may fuse at one instrument setting only, the slightest movement of the tubes causing diplopia.

Variation in size of fusional element may be the means of overcoming these difficulties by finding a target to which he can give a satisfactory response to establish a starting point. I usually find that the smaller the target, the more accurate the fusion response. I believe that foveal, macular, and peripheral (25 mm.) targets are all necessary for antisuppression training as they seem to require and subsequently to develop somewhat different levels of fusional ability.

Development of fusion range. It is generally believed that the larger the target, the greater is the fusion range which can be developed. From recent personal observation, it has seemed to me that the size of the target makes little difference in the amount of divergence but a definite difference in convergence, a larger slide stimulating increased convergence. This would not hold true where the element of accommodation entered the picture to any great extent.

Third grade slides are also useful to stimulate convergence. This may be due partly to the sense of nearness created if the slides are inserted so that the stereopsis element seems to approach the patient increasingly as the tubes are converged. In third grade targets again, small centrally spaced controls add to the slide's effectiveness. One other observation relative to third grade slides is that since a comparison of relative distance from the observer is involved, more than one stereopsis element is usual. A number are sometimes used. Any two elements to be compared must not be too widely separated, as relative position cannot be judged accurately in a slide unless both objects can be seen clearly without change of focus.

Development of relative accommodation. Since the eyes can attain parallelism by the time this step is reached, the troposcope is less important than training by other means. The Kramer "Accommodative Series" of slides with graded print are useful. Additional similar slides would add variety and help to avoid memorization.

TEMPORAL OCCLUSION IN CONCOMITANT CONVERGENT STRABISMUS

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THIS paper deals with a form of occlusion which has been successful in the initial treatment of many cases of amblyopia.

It is a well-known fact that the monocularly squinting patient whose deviation became manifest and constant during the first year of life has very poor visual acuity in the deviating eye. Probably due to the almost complete lack of central fixation experience, this eye will fixate eccentrically when the other eye is covered. Needless to say, such a patient is severely handicapped by total occlusion of the habitually fixating eye. If the case is neglected until school age has been reached, additional discouraging factors complicate the occlusion program and it is often given up as hopeless. On the other hand, if partial occlusion is used first *on the amblyopic eye,* a number of these problems are bypassed.

The majority of amblyopic patients have a convergent squint. Images of fixated objects have been received on the nasal retina of the nonfixating eye habitually. By occluding the *temporal* portion of the glasses (lens and frames) in front of this amblyopic eye, all stimuli to the nasal retina are excluded. This in itself constitutes both passive and preventive treatment of anomalous retinal correspondence. The only stimuli then received by the partially occluded eye pass through the open nasal portion of the lens and are received upon the temporal retina.

It would seem that the unpatched nasal portion of the lens actually is the important part of temporal occlusion. The two halves of the retina act differently with regard to optomotor reflexes, and there is a possibility that the exclusion of the nasal half of the retina (which contains crossed pathways) may reorient the optomotor reflexes by allowing only a stimulation of the temporal half of the retina of the deviated eye (which contains uncrossed pathways).

The temporal occluder is made to adhere to the patient's glasses and is worn constantly during waking hours. Mystic tape used over a base of gummed paper provides the requirements for shaping and durability. This cone-shaped occluder covers the inside as well as the outside of the temporal portion of the glasses, allowing no reflection from the glass or frame. In determining how much of the lens is to be covered, a small light, held at approximately 30 centimeters in the midline position, is fixated by the patient with his dominant eye (glasses on). The lens before the deviating eye is marked at the point where the corneal reflection is seen by the observer. The occluder is placed so as to cover this point.

When age readiness permits, the suppression area is plotted on the major amblyoscope before starting temporal occlusion, using targets which are large enough to be perceived by the amblyopic eye. Starting at the objective angle, the arms of the instrument are moved toward zero. The point at which simul-

taneous perception is lost and the point at which it is recovered mark the extent of the suppression area on this excursion. Then the movement of the arms is reversed to measure the area of suppression on the excursion toward the objective angle. The findings on these two excursions usually differ from each other and the suppression area may vary in size from a large area to a mere crossing point. Critical observation on the part of the patient is an important factor in making these measurements.

In four to six weeks, if temporal occlusion of the amblyopic eye has been followed faithfully, the suppression area will be reduced. Coincidentally there also may or may not be (1) a change in the character of fixation in the amblyopic eye, (2) a decrease in the angle of squint, and (3) an increase in the visual acuity of the amblyopic eye.

Thereafter it is advisable to see the patient at weekly intervals so that (1) the occluder can maintain its proper position relative to the corneal reflection (as the deviation changes), (2) major amblyoscope technics may be employed to help teach awareness of the relative position of the two eyes, and (3) repeated measurements (of the suppression area) can determine the stage at which total occlusion of the dominant eye should be started. Ideally this stage is recognized by (1) crossing of the images at or near the objective angle of the major amblyoscope and/or (2) wavering of the previously fixed eccentric fixation.

In some cases, the suppression area seems to increase again with full occlusion of the dominant eye. When this occurs, temporal occlusion of the amblyopic eye may be resumed briefly or alternated with full occlusion of the dominant eye.

It is obvious that the dire need for more help in cases of severe amblyopia and eccentric fixation prompted the first use of temporal occlusion. For the purpose of simplification, only its application to such cases has been described in this paper. The following case history briefly summarizes the progress of a patient in this category.

O. H.
Age at onset, birth
Age at first orthoptic exam, 6 yrs.
Refractive correction,
O.D. $+1.00+2.00\times 90$
O.S. $+1.25+1.25\times 110$

(above correction worn for following measurements):

June 1951

V/O.D., 6/6
V/O.S., 1/60
Obj. angle, 44△ B.O. (tropo)
Fixation:
O.D. central
O.S. fixed eccentric
Retinal correspondence, anomalous
Area of suppression,
34△ (excursion away from objective angle)
30△ (excursion toward objective angle)

October 1951, *following* 4 ***months temporal occlusion O.S.***

V/O.D., 6/6
V/O.S., 6/60
Objective angle, 30△ B.O.
Fixation:
O.D., central
O.S., wavering
A.R.C.
Area of suppression, $\frac{20}{16}$

January 1952, *following* 3 ***months full occlusion, O.D.***

V/O.D., 6/6
V/O.S., 6/20
Objective angle, 22△ B.O.
Fixation, central O.U.
A.R.C.
Area of suppression, images "jump" (angle of anomaly 16△)

June 1952, *following additional* 5 *months full occlusion, O.D.*

V/O.D., 6/6
V/O.S., 6/6
Objective angle, 10△ B.O.
N.R.C.
Area of suppression, images "jump" at objective angle

December 1952, *following* 6 *months alternate occlusion* (O.D. × 5
O.S. × 2) weekly
V/O.D. 6/6
V/O.S. 6/6
Objective angle, 20△ B.O.
Area of suppression, $\frac{0}{0}$ (fusion at obj. angle)
Patient will need surgery. Orthoptics is being employed meanwhile to build amplitude.

The encouraging results obtained in the treatment of amblyopia have led to the application of temporal occlusion in other forms of binocular incoordination. It is to be expected that increasing use for this type of initial occlusion will be found as more experience with it is gained.

AN EVALUATION OF HOME TRAINING IN ORTHOPTICS

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A CHALLENGE as well as an opportunity is offered the orthoptic technician in the ever-present need for effective methods to be used in carrying out orthoptic training at home. Since our work as orthoptists lies in encouraging the forming of correct habits—specifically, correct binocular habits—and since habits are formed through constant repetition, we automatically are faced with the problem of how to prescribe work that will give the greatest amount of practice in building up these habits. In this thought lies the real reason for home training. Repetition is vital, and daily repetition much more effective than practice carried out once or twice weekly. In the words of Julia Lancaster,[2] "Adequate opportunity for repetition of the right responses must be provided if learning is to become established as a habit."

We are soon confronted with the fact, however, that an exercise done incorrectly is of no value and one done without interest and purpose is of very little use. As stated by Frances Walraven,[5] "Unless exercises are given correctly, the child would much better be playing outside." It is here that the skill of the orthoptist is put to a difficult test in the task of directing binocular training that is meaningful. It would often be simpler to bypass this phase of orthoptic training, but it could be disastrous to do so. Ideally we work with patients during a formative period, but this is usually not the case. More often than not, discouraging a wrong habit necessarily precedes teaching a right one. The many obstacles that are encountered in this process of first breaking down and then building up necessitate vigilance in the seeking of effective training methods. Miss Lancaster's aptly expressed thought comes to mind with increased meaning as we direct home training, that the carrying over of correct habits into casual everyday use of the eyes is the difficult and tedious task that must be coped with constantly. The careful supervision of this transition we cannot escape. "Off the instrument" work is obviously of the utmost importance, and this is one type of orthoptic training that can be done at home *if* well directed by the technician and enthusiastically carried out by the patient. A certain amount of exercise can be carried out passively by the patient, but the time soon comes when the patient must actively work at his assigned task. An intelligent and cooperative parent is a great asset. There is a limit to what the orthoptist can accomplish alone.

Perhaps I should insert the thought here that home training is not a part of the treatment of every orthoptic case. The prescription of training at home is dependent upon the binocular ability of the patient. There are many instances where only supervised office training is indicated. Patients with abnormal retinal correspondence are never given unsupervised binocular training. Only monocular work is given these patients away from the office or clinic. I am thinking of that rather high percentage of patients who can carry out directed work to advantage. In the words of Elizabeth Stark,[4] "In addition

to normal retinal correspondence, a patient suitable for home training should demonstrate some ability to fuse images at his angle of deviation on an instrument providing satisfactory objective control, and he should have some range of fusion."

OVERCOMING SUPPRESSION

Orthoptic treatment has at times been referred to as antisuppression treatment. Certainly the first step in developing binocular coordination is teaching an awareness of what each eye is seeing and of where each image is projected. In this interest any suppression habit that is present must be broken down. Only through such an awareness can the patient be given an opportunity of knowing what to do to put forth a conscious effort to help himself. This all-important step takes precedence over any other type of training. A certain portion of training is in the hands of the technician, or at least requires effort on the part of the technician alone, but the point is quickly reached where the person supervising the training is helpless without the conscious effort of the patient. Home training then enters into two phases of over-all orthoptic treatment. First, it is helpful in teaching an awareness and later in overcoming the wrong situation of which the patient has become aware.

The preliminary step to breaking down suppression and teaching an awareness is the equalizing of vision to whatever extent it is possible. I believe there would be no difference of opinion concerning the fact that best results are accomplished through constant occlusion when amblyopia ex anopsia is present and that vision is stimulated more quickly when occupation requiring as acute use of the amblyopic eye as is possible will increase vision in the shortest time. I would like to mention a method of occlusion, however, that has proved to be helpful in many instances. When a child is wearing glasses and has reached the point where he can be counted on to wear his glasses constantly, we have found a felt occluder to be simple, inexpensive and effective. Felt in black or grey can be purchased by the yard and cut to the desired size and shape. Two small holes will serve to slip the felt on the temple of the frames, and one slit at the nasal side will allow the felt to be attached firmly on the nose piece (fig. 1). When metal spectacle frames are worn, this method of attachment is sufficient, but when plastic frames are used, the felt will have to be tacked at the nasal side after the nose piece has been put through the slit. The felt is cut large enough to prevent peeking at the edges and to allow good occlusion without the need of taping to the face. Of course there are times when nothing will supplant adhesive or elastoplast patching, but in other instances the felt is sufficient and proves to be more effective than a simple covering of just the lens itself. When vision becomes equalized to the extent that binocular training is feasible, often some method of partial occlusion is helpful.

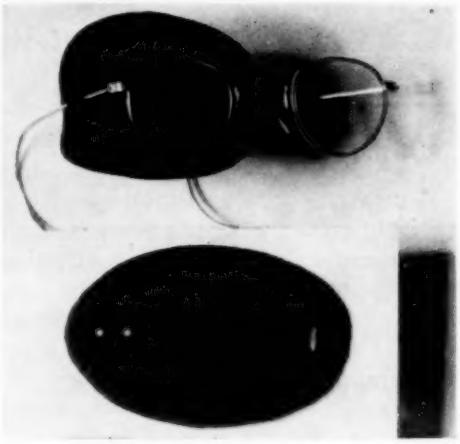

FIG. 1—Felt occluder for use on glasses.

CONDITIONS BENEFITED BY HOME TRAINING

Accommodative Squint

This brings us to the consideration of the conditions most benefited by home training. Possibly one of the conditions most adaptable for work at home is the accommodative squint. There are many approaches to the end accomplishment of a patient who has learned to accommodate without converging to excess: the method of prescribing a full correction of plus power with the idea of gradually decreasing it, the method of substituting occlusion for a high plus correction, the bifocal method, the plus clip-on method, etc. It is not in the province of this paper to weigh the merits of these various methods. We are all agreed, however, that our goal is the dissociation of accommodation and convergence and the comfortable maintenance of straight eyes for distance and for near with and without glasses. It is true that many children grow less hyperopic in time, and the problem is lessened by nature. During this growing period, however, wrong habits can easily be developed if the patient is left unsupervised. With a patient of this type the element of time is an important factor and one cannot be hurried. This very fact is one reason for the direction of training at home. Often it is not feasible for the patient nor possible for the busy orthoptist to schedule an unbroken series of frequent office visits, but directed periods of home training can be conveniently and beneficially planned and interspersed. Later on, when the time is propitious, the patient will make faster progress because of his preliminary homework.

In the interest of stating the value of home exercises more clearly, I would like to make a distinction between the accommodative convergent squint that requires only one refractive correction for the maintenance of straight eyes for distance and for near and the condition in which straight eyes are maintained for distance with glasses but in which a convergence excess is readily demonstrated on near fixation. To clarify further the use of home training, a subdivision of the last-mentioned condition is necessary. There is the patient who converges to excess on near fixation for the purpose of clearing vision and the patient who can read Jaeger 1 with straight eyes but who still inexplicably converges to excess in a spasmodic manner.

To resume consideration of the preliminary step of occlusion, I would like to refer again to partial occlusion. I would recommend as of definite value in our experience the use of lacquer on a lens. In addition to the use of lacquer as a means of bringing about further stimulation of the vision of the nondominant eye, there are times when lacquer carefully used and closely watched can almost in itself bring about the maintenance of parallelism. If the condition is such that binocular use of the eyes is not possible except on the instrument, there would be nothing to gain by the use of lacquer. Complete and constant occlusion would best be continued until equalization of vision is achieved. It is when binocular use of the eyes is possible that dimming instead of occluding one eye is beneficial. In this way binocular vision can be encouraged while vision is still being stimulated.

The need for a slight dimming of the vision of one eye is most acute when a convergence excess is present over and above the amount of squint taken care of by the glasses worn. These children with straight eyes for distance and with a spontaneous esotropia for near rarely report diplopia at near, at least at the outset of treatment, and badly need help in maintaining binocular fixation. Often when a refractive error is not present at

all, plano lenses are prescribed for close work so that lacquer can be used for training. Of course those children who cannot see clearly at near with straight eyes are not the ones helped most by lacquer, such a child would be inclined to fix with the eye whose view was not obstructed. These children are usually taught to recognize blurry vision when eyes are held straight and to maintain it at will. They then must learn to clear the blur. In the course of treatment either occlusion or stronger plus lenses for near can be resorted to temporarily. It is the large group of children who have clear vision with straight eyes for near but who still show a convergence excess who are the ones particularly benefited by the use of lacquer. However, even squints who show no deviation for distance or near while glasses are on but who manifest an esophoria or esotropia without glasses often are helped by dimming vision of the dominant eye with lacquer. It is harder to force the use of the nondominant eye when occlusion is not complete, so a more difficult task is presented when vision is only dimmed rather than cut off completely. The thickness of the lacquer can be varied to suit the condition. Our experience has been that one of the clear top coats of nail polish advertised dries more quickly and is more readily removed. The problem of removing lacquer when the lenses are mounted in plastic frames is solved by making use of a small cotton swab. A discussion of partial occlusion would not be complete without mention of vertical stripping as described by Lyle and Jackson.[3] Strips of mending tape cut in 2 mm. widths and placed on a lens, spaced according to the degree of occlusion desired, also serve as a very effective method of dimming vision.

When the stage has been reached for diplopia to be taught, the use of a red glass to teach differentiation of the images of each eye and the dividing of the fields of vision by a barrier extending from the nose in some form are methods that cannot be supplanted. We can only make convenient variations based on these accepted methods. In the interest of the exchange of ideas on

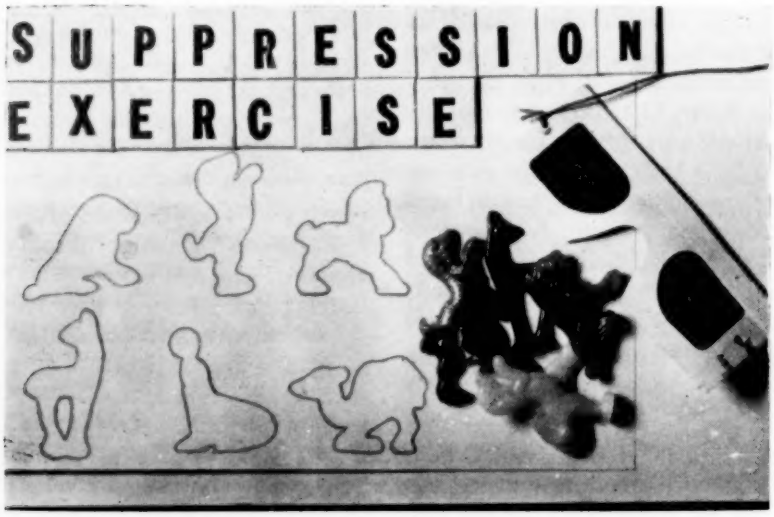

FIG. 2—Suppression exercise with filter.

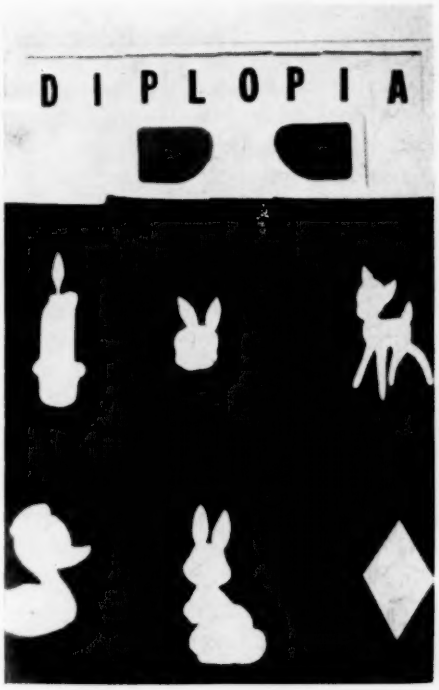

FIG. 3—Diplopia exercise with filter and silhouettes.

these variations, I mention the following uses of the red filter or red-green or red-blue filter for suppression work. One slight advantage of using the two colored filters is the fact that a red tracing which is obliterated by the red filter is made darker and even more distinct by blue or green and may at times afford sooner use of this type of exercise. With the filter adjusted with the red over the dominant eye, tracing a red drawing, placing objects in spaces drawn to shape on a white card (fig. 2) — blocks, cardboard pictures or plastic toys — jigsaw puzzles with the shapes of the various pieces traced on a board or a white marble board with some of the holes ringed with red can all be made helpful suppression devices. It is of value to give the parent a packet of five or six cards with such tracings and pictures to take home to use as a guide for further games that she will necessarily have to devise. Often creative parents will have very ingenious ideas to offer. One such parent draws a maze of red and has her son push little cars along the maze from beginning to end. She also makes designs on cards by drawing around pennies. Pictures can be drawn in red and then cut into several pieces to be fitted together as a jigsaw puzzle. Little girls can embroider red designs on towels, etc. Now these are more or less passive suppression exercises and are used just as soon as the vision of the weaker eye will permit, or just as soon as fixation of that eye is good enough. With deep suppression it is important to guard against the patient's closing the dominant eye. This, of course, would defeat the purpose of the exercise. It is sometimes necessary at first to dim the red side of the filter to allow sufficiently good fixation to permit the exercise to be carried out.

More active suppression work is done by use of the red filter and a light or white silhouettes (fig. 3). The patient must put forth more effort when trying to learn to alternate fixation on command and then to recognize diplopia. We find that white silhouettes cut in different shapes and given out for home use, then swapped from week to week, stimulate interest. Ideally, of course, the use of a glowing white picture can be worked out by putting a black cardboard disc with a cut-out in it on the end of a flashlight. Interested parents will do this. For office use I would suggest a Scout flashlight which will stand and cast a light from the side (fig. 4).

In teaching diplopia by some means of separating what each eye sees, we are constantly in search of a convenient means of bringing this situation about. Frances Walraven has provided us with a very ingenious means of accomplishing this with the development of the

FIG. 4—Scout flashlight with cut-out for lighted target.

Walraven Bar Separator, by which controlled binocular training is given at reading distance. Through its use the portion of the picture or page seen binocularly is immediately seen double if an eye deviates. An unobstructed view of the patient's eyes is provided. Excellent control can be developed as the patient gradually is taught to maintain single binocular vision as smaller pictures and print requiring more accommodation and more acute fixation are presented in the Separator. The construction of this instrument is such that the head rests steadily against a curved bar and the material presented is held firmly in place by a metal clamp. Let me stress that the Bar Separator is a device designed to provide a means of achieving and stabilizing bifoveal fixation. It provides the final step in what might be called in the vernacular, "clinching" the result. Many patients might be considered ready for dismissal who under stress or under conditions such as are provided by the Bar Separator cannot maintain steady binocular fixation. Stabilizing fusion on the Bar Separator is not an easy task, but I would recommend its use as being well worth the time and effort spent encouraging the patient to master it.

As a preliminary step to using the Bar Separator and as a means of preparing the patient for work on the Separator, we often make use of a simple device which we have developed out of necessity and which we rather loosely, for convenience sake, speak of as a nosebar. The value of the nosebar lies in dividing the fields of vision without having to hold a card by hand and in being able to begin work as far away from the patient as is necessary. An object can be fixed at 20 ft. and then can slowly be moved closer. This very simple training device

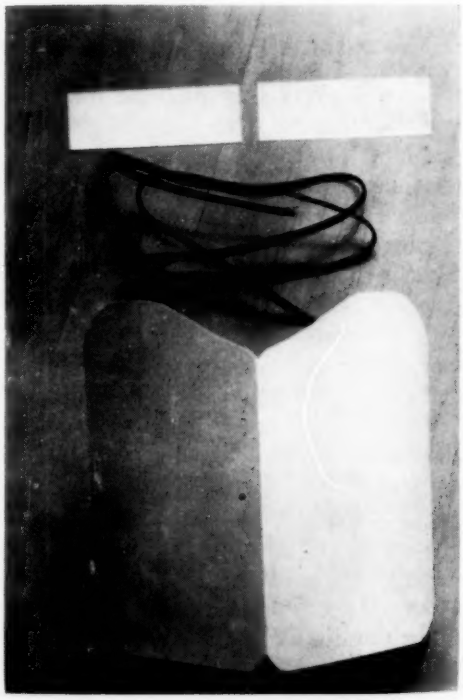

FIG. 5—Materials used in making the nosebar.

allows diplopia to be taught conveniently without demanding very acute fixation. Of course, the closer the object fixed is brought to the eyes, the smaller the binocular field and the more difficult the task of maintaining single binocular vision. A nosebar such as we construct is made with the following materials: one standard 5 by 8 inch filing card folded in half the short way, two strips of lightweight cardboard 2.5 inches by 1 inch and a 22-inch piece of elastic (fig. 5). The large card is placed with the fold at the top and is stapled together at the outer edge and at the outer end of the bottom edge. The portion against the nose is left open so that the card can be anchored on the tip of the nose (figs. 6 and 7). The two small pieces of cardboard are stapled at the top of the card and bent outward across the forehead. The elastic headband is taped to these strips and tied in the back. In this manner the nosebar is held in place. It is easily and very inexpensively constructed and given to our patients to use at home with greeting cards and picture books, and later on with story books as the child learns to read. It can also be used with a silhouette and a red cellophane curtain attached to hang over one eye. The nosebar in no way supplants the Bar Separator. It is only a preliminary step to more stimulating and advanced work with the Separator.

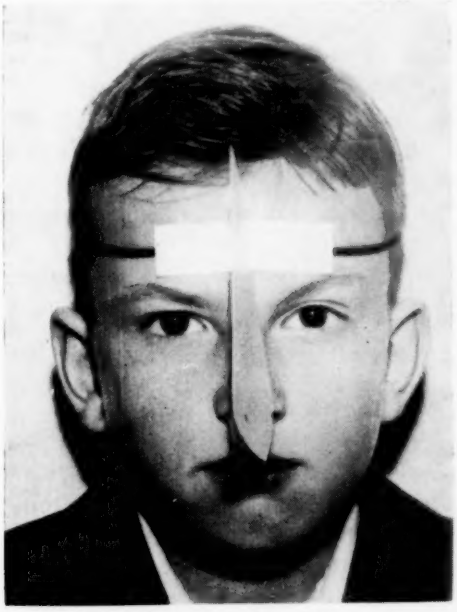

FIG. 6—Nosebar in place (front view).

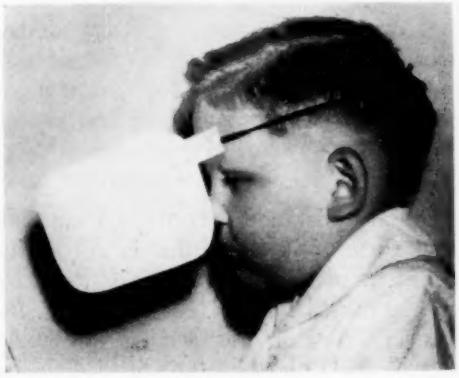

FIG. 7—Nosebar in place (side view).

Use of the stereoscope for the strengthening of fusion ability and depth perception and for building up vergence power with the use of the many standard sets of stereoscopic slides available has long been recognized and endorsed. I believe we are indebted to Elizabeth Stark,[4] however, for early mention of the possibility of augmenting our slide supply with charts of our own making. Her original idea of building up a sort of chart circulating library has proved invaluable to us, and I recommend this to you. Cards can easily be obtained cut to size, and many suitable pictures are available from greeting cards, picture books, tally cards and children's card games.

Just recently we have become acquainted with a very simple device called a Tri-Scope, although earlier mention has been made by others of this

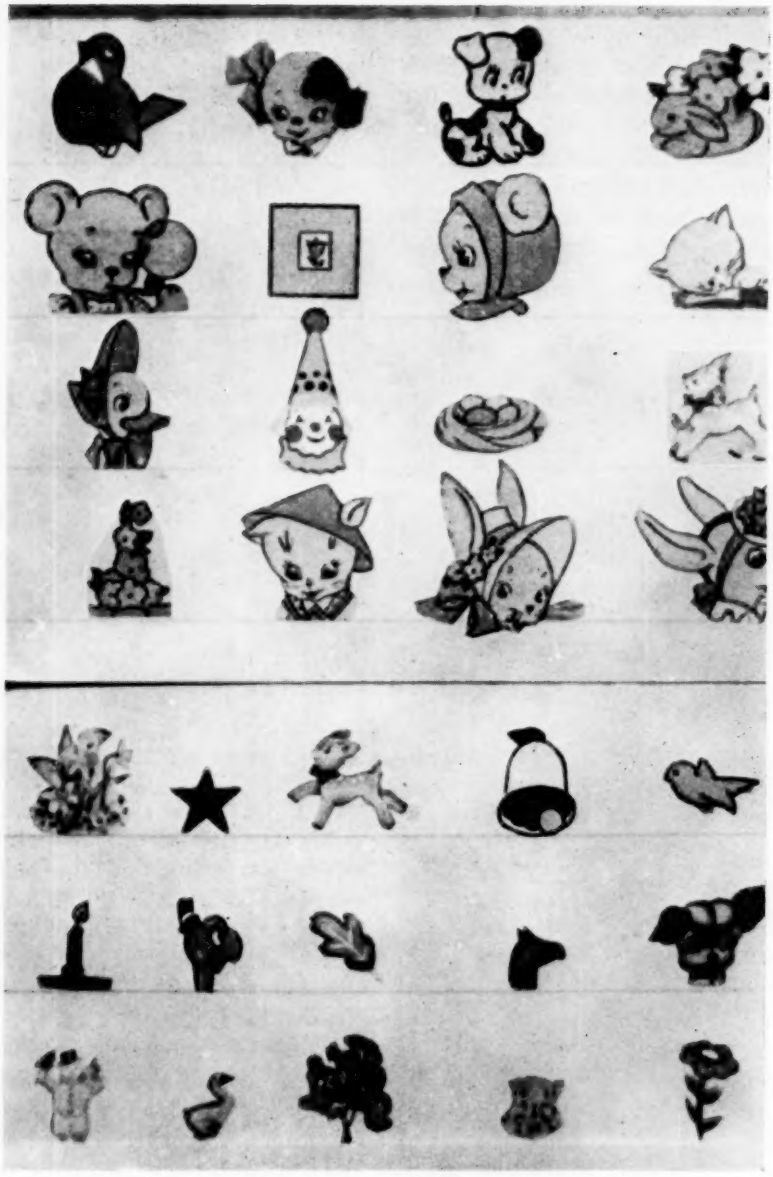

FIG. 8—Graduated picture cards for use with a reading bar.

simple but useful device. It is one of the many adaptations of the stereoscope so popular now for entertainment purposes. The advantage of this particular one for very young children, in addition to the cartoon-type slides, is the arrangement of the eyepieces. A child with a pupillary distance of only 4.5 cm. can make use of it. Since this is not an instrument designed for training, control marks must be added. If desired, prisms can be taped on the eyepieces. The result is an interesting and useful variation for fusion training at home.

In enumerating helpful measures for home training, use of the reading bar must not be omitted. Thinking particularly of means of developing control over an excessive convergence tendency for near, use of the bar for framing, first at distance and gradually at decreasing distances, is an excellent way of strengthening the maintenance of single binocular vision. With preschool children, after framing has become possible for near, cards with rows of increasingly small pictures can be made for use at reading distance with the bar (fig. 8). Names of the pictures in corresponding lines can be typed on the back of the card for the use of the person conducting the exercise.

Convergence Insufficiency

In thinking of types of conditions particularly benefited by home training, that of convergence insufficiency quickly comes to mind. I suppose that no other condition is so readily helped by daily work at home, but I say this with reservations. I am sure that we all at some time have attempted to work out a home training program for a convergence insufficiency case, only to find that the patient was utterly incapable of carrying out convergence work unsupervised. By this I mean that the element of suppression was so strong that there was no awareness whatsoever on the part of the patient of what the two eyes were doing and therefore no way for the patient to work alone to any advantage. Perhaps only a few periods of supervised work may be necessary in such instances, but these few visits are often essential in prescribing helpful home training. We cannot casually put convergence insufficiency cases in one category; there are many variations of this one type of case. A dangerous pitfall is ever-present in the possibility of failing to recognize the limitations of the binocular ability of a patient before prescribing home training. Another constant danger and a reason often for the deprecation of the value of home training lies in expecting too passive a training program to produce results. But this group of cases—the convergence insufficiency group—is one of which we must take notice. These are uncomfortable patients, often adults with occupational complaints who need to be made comfortable in carrying on in their already chosen profession. I agree with Electra Healy's statement,[1] "Convergence insufficiency probably causes more discomfort than any other one condition and is also, as a rule, one of the easiest to correct."

As in any orthoptic case, the first step is to break down suppression. The great majority of convergence insufficiency cases are adults, so very often a deep-seated suppression is present. The first step in breaking down suppression is identical with that of any other condition where suppression is present. Tracing rather intricate red drawings is particularly good for these adult patients who rarely seem to resent the kindergarten character of this exercise. As soon as the patient can recognize diplopia with a red glass at arm's length—a distance which is often easiest—he is given a filter and a white silhouette to use, trying to maintain a single pinkish picture as he moves the object nearer. The next step is this same exercise used with a square prism base out covered with a double thickness of red cellophane. The prism strength is increased as prisms are swapped from treatment to treatment. Working distance is gradually increased to 20 feet and further and decreased to 3 cm. The cellophane can be removed from the prism as soon as diplopia is recognized without the help of differentiation by means of color. When suppression is sufficiently overcome, the patient is given a strip of cardboard slightly less than an inch wide

with a tiny picture pasted on one end. This is used as a fixation object as he is taught to recognize physiologic diplopia and maintain binocular fixation as the picture is brought nearer. A small picture is far more stimulating for this exercise than a finger, a pencil or a light. Later on, the patient is taught voluntary convergence by learning to maintain fixation on an imaginary object as he quickly drops the picture and keeps a doubled image in the distance.

Fusion is strengthened by use of a stereoscope with Keystone base out slides, or by use of a View Master, a stereoscope-type instrument designed for entertainment and particularly adaptable for adult use. The wide range and type of slides available and the ample distance between the eyepieces make this device preferable for use by other than very young patients. Small ink dots on the slides serve as control marks. Prisms taped on the eyepieces make possible the development of vergence power. Other excellent training instruments that can be used to good advantage at home as well as in the office are the Ortho-Fusors and the Vectograms. These are devices used with polaroid glasses and designed for the definite purpose of building up vergences and furthering the development of stereopsis.

Divergence Excess

Another condition helped to some extent by home training is that of divergence excess. By "some extent" I mean to imply that less often does orthoptic training serve as the only necessary means of overcoming this condition. Often more drastic measures have to be employed. It is entirely possible, however, to accomplish a great deal, particularly by teaching an awareness of diplopia at distance, where suppression most often occurs in these cases. It is well, too, to employ all possible means of strengthening fusion.

Divergence Insufficiency

With reference to home training still one other condition, that of divergence insufficiency, is worthy of mention. As with divergence excess, however, the prognosis with training alone is not as certain. Use of a stereoscope with base in slides has been, in our experience, a most effective training means for these cases, and this type of training can readily be done at home. Since the building up of prism divergence is such a gradual and painstaking procedure, the carrying out of daily work gains importance in cases of divergence insufficiency. Progress is usually made slowly, and alleviation of discomfort from this condition is delayed somewhat. One other method of home training of value when diplopia can be recognized is the use of recession exercises with base in prisms.

The afore-mentioned facts concerning home training are not intended to represent an exhaustive study of this phase of orthoptic treatment. They are presented with the idea of bringing to mind a few pertinent thoughts concerning ways in which a patient can, with supervision, shorten the length of his over-all training period and can help himself attain the goal of comfortable, correct binocular coordination.

CONCLUSIONS

In conclusion I would like to stress the following facts.

1. There is definite value in the daily repetition of correct responses with reference to bringing about a good habit of binocular coordination.

2. Home training is an essential phase of orthoptic treatment and should be taken into consideration in the over-all training program of most cases.

3. Home training, as such, must be qualified. Inexpertly directed and carelessly carried out, it is of no value. The orthoptic technician must feel keenly his or her responsibility in supervising this important phase of orthoptic work.

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PHYSIOLOGIC DIPLOPIA AS A HOME EXERCISE

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THE IMPORTANCE of physiologic diplopia as a home exercise cannot be stressed too much. Although physiologic diplopia is normally suppressed in single binocular vision, it is one of the criteria for normal functioning of the eyes. One must insist upon its presence before a patient can be deemed functionally cured.

In one form or another physiologic diplopia can be applied to a great many patients. Those patients who suppress although they keep their eyes straight, can learn to recognize their suppression and begin to make constructive moves toward combating it. As a matter of routine we teach physiologic diplopia technic to all patients with convergence insufficiency, having them alternate fixation at reading distance with fixation of more remote objects at varying distances.

Physiologic diplopia is also a valuable preoperative exercise when it is possible to achieve fusional amplitudes within the angle of squint. In this instance it should be used in conjunction with occlusion and other types of exercise, or it may be used as a postoperative measure to reinforce single binocular vision and build fusional amplitude in the new position.

Before attempting to teach physiologic diplopia to anyone, there are several prerequisites which must be met. The first of these is normal retinal correspondence. A patient with a small angle of squint and a small angle of anomaly may describe a form of anomalous diplopia which will be reinforced by exercise. A full set of diagnostic tests for retinal correspondence should be run if there is any doubt as to the nature of correspondence. Some patients have normal retinal correspondence for one distance and anomalous retinal correspondence for another distance or normal retinal correspondence for one test and anomalous retinal correspondence for another test. In such cases it is essential that physiologic diplopia, if attempted, should be limited to the area in which normal retinal correspondence is well established.

The second and third prerequisites are steady fixation and a reasonably long attention span. I mention these two together since they so often go hand-in-hand. Sometimes the wavering fixation is due to a short attention span rather than visual limitations. However, if the fixation is poor, monocular training and some form of occlusion must be instituted before training with physiologic diplopia. In an attempt to lengthen the attention span controlled alternation with a red glass may be begun as the vision becomes more nearly equal. In many cases it is necessary to concentrate on passive measures, such as occlusion, until the child has reached a more favorable age.

The last, and perhaps most important, prerequisite is the selection of patients who have fusion at some point within arm's length. A convergent angle of squint must not be too great to allow fusion at a point 5 cm. from the bridge of the nose. A divergent condition must allow fusion at a near point which is no more remote than the distance at which the patient can hold a small object or a light.

We find it necessary to choose carefully the patients who are allotted time for intensive orthoptics in the office. Because of the distance and time elements involved, they are given five or six treatments on three consecutive days at the stage where this amount of time can be used to best advantage. Prior to this, however, one may add or elaborate upon simple preliminary home technics at each visit. These visits usually occur at two to four month intervals.

It is important that parents have good insight into the problem and are capable of supervising the home training technics. Some form of diplopia exercise is often more easily and quickly learned than the stereoscope technic, and sometimes the deviation is too great to allow use of the stereoscope. The teaching approach, the exercise itself and the length of time spent practicing are variables that change with the patient. The flexibility of such "off the instrument" treatment is one of its main advantages.

When a diplopia exercise or technic has progressed to the physiologic diplopia stage, it fills a most important need, namely that of a preoperative measure for gaining amplitude where intensive orthoptics in the office is impractical or impossible.

PROCEDURE

Assuming that the patient has the necessary prerequisites, we lead up to the physiologic diplopia exercise with a series of preliminary steps. If amblyopia ex anopsia is present, the usual occlusion is carried out until equal or nearly equal vision is obtained. At this stage the child is taught to alternate voluntarily. With a red glass over one eye, he sits facing the observer, who holds up a small flashlight. The observer should at all times keep a close watch on the patient's eyes. The patient is asked to "find the red light, then find the white light." He should learn to hold fixation with each eye at least until the count of ten. Sooner or later, this procedure can be followed without the red glass. During the period when this exercise is being used for a few minutes each day (occlusion being interrupted for the exercise only) the child may or may not describe diplopia spontaneously. It may be necessary during an office visit to produce diplopia with a vertical prism. This also provides an opportunity for reaffirming the status of retinal correspondence. If the lateral displacement is less than the angle of squint, the alternation exercise is resumed. However, if the lateral displacement is equal to the angle of squint, one can safely ask the patient to try to find the two lights simultaneously without the help of the vertical prism. It sometimes helps to describe the probable positions of the two lights. Or it may be helpful to have him hold fixation with one eye during a quick "cover and uncover" of either eye. After diplopia with a color filter has been established, he may be able to recognize diplopia without a filter.

The next step is to move the target backward and forward until fusion is achieved. If the patient continues to be unable to recognize diplopia without a color filter, fusion exercises with the filter can be carried on until color differentiation is no longer necessary. At any time it may be possible to vary the target used. A white-headed pin placed in the eraser of a pencil may be used instead of the flashlight. It is important, however, to use a small distinct target (white, of course, if color differentiation is desired).

Once single binocular vision has been established at any one point, a gain of amplitude is attempted by moving the fused target backward and forward keeping fusion (as in the clothes pin exercise). In an intell gent and discern-

ing patient, an amplitude of 3 inches is sufficient to allow recognition of physiologic diplopia. In other patients a range of 8 to 10 inches is needed. It sometimes is possible to gain amplitude by first finding the near point, then moving the target backward and forward while the patient retains fusion.

To encourage the recognition of physiologic diplopia in a case of esotropia, a white veil pin or flashlight is held at the patient's convergence near point. Another flashlight is held farther out but still within his fusional range. He is asked to look intently at the near object while he thinks about the more distant one and vice versa. As with the earlier routines, it may be necessary to use at first a red glass or Macyscope (for color differentiation). This also provides a means of checking the patient's responses. When the near object is fixated, the more distant object should be seen in the position of homonymous diplopia. When the distant object is fixated, the near object should be seen in the position of crossed (heteronymous) diplopia. It is well to insist that the fixated object be centered between the two diplopic images and held in that position for at least 10 counts. Amplitude of fusion is gained as a greater distance between the two targets is tolerated.

In exotropia, it obviously is necessary that the patient be able to fuse at some point within arm's length in order to experience physiologic diplopia. Here, too, one would begin with the patient's convergence near point. Since this is likely to be remote, the second object would be held at a nearer point. Amplitude is gained in proportion to the separation at which physiologic diplopia is described.

If possible these physiologic diplopia exercises should be correlated with the use of the major amblyoscope and with other home exercises such as the stereoscope. Orthoptically speaking, when the maximum amount of visual acuity and fusional amplitude has been gained the patient is ready for surgery. Little more can be done until the eyes have been set straight.

Following surgery the preoperative experience of physiologic diplopia should carry over to the postoperative condition. If the child still has a small residual convergent angle of squint, it may be necessary to begin within his angle and try again to increase the amplitudes. If he has a remote near point postoperatively, it will be necessary to resume physiologic diplopia exercises, placing emphasis on voluntary convergence to improve the near point.

Ideally, then, the patient with a heterotropia who has received the benefit of appropriate orthoptics and surgery will be converted to a heterophoria.

The simple physiologic diplopia exercise we use for heterophorias, postoperative or otherwise, is as follows:

1. A pencil used as a near target is held at reading distance (approximately 13 inches). Any object at a distance beyond 13 inches may be used as a distant target.

2. The patient looks at the top of the pencil and experiences homonymous diplopia of the distant object. This position is held for a given number of "counts" with the fixated object centered between the diplopic images. If he has difficulty recognizing the two images a colored filter and white targets or lights can be used first.

3. He then looks at the distant target and likewise keeps the near image in a position of crossed diplopia.

4. The above steps are repeated (under supervision in the case of a young child) at least ten times daily in one or two exercise periods. The nature and distance of the distant target should

be varied and may include material for "bar reading."

The criteria for complete mastery of such an exercise is the ability to (1) converge the eyes voluntarily without a target stimulus, and (2) demonstrate single binocular vision for any test, distance or near, with or without an instrument.

An important outcome of faithful adherence to training technics, is the patient's insight into his problem, and his awareness of any recurring suppression.

We rarely use physiologic diplopia as the only home exercise for patients with asthenopic symptoms. For this reason it is difficult to assess its unique value in relieving symptoms. We are confident, however, that it is an extremely valuable supplementary exercise and one to which the patient may readily turn if his symptoms recur. Whether physiologic diplopia could relieve symptoms without any conjunctive exercises is a moot question.

In summarizing, it is obvious that there are insuperable obstacles to physiologic diplopia which we as orthoptists cannot overcome. Orthoptically the most important of these are amblyopia and anomalous retinal correspondence, which do not respond to treatment.

As in most learning processes, if the child is too young to understand the directions or too restless to pay attention, we must await age readiness. If he is mentally incapable of following instructions, we cannot use our time to any advantage. If his parents are indifferent or do not adequately supervise his home exercises, they nullify any initial work which has been accomplished at an office visit. The obstacle least encountered is *horror fusionis*. Although this is rare we are justified in suspecting its presence when no other obstacle to fusion can be found.

After ruling out the above situations, physiologic diplopia is accepted as an indispensable auxiliary exercise. It helps to gain a functional result in many cases which otherwise would have a cosmetic result only. It affords an opportunity to transfer the skills developed on the instruments to casual seeing. Certainly it deserves a definite place in our repertory of home exercises.

THE AMERICAN ORTHOPTIC COUNCIL — 1953

The American Orthoptic Council is composed of three representatives each from the American Ophthalmological Society, the Section of Ophthalmology of the American Medical Association, the American Academy of Ophthalmology and Otolaryngology, and the American College of Surgeons. Four associate members are elected from the American Association of Orthoptic Technicians.

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AMERICAN ORTHOPTIC JOURNAL

Published Annually as a Supplement to the Transactions of the American Academy of Ophthalmology and Otolaryngology

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Editorials

ORTHOPTIC THERAPY

At intervals (probably not often enough), we must reconsider "why orthoptics is." What good purposes should it serve? Does it serve them fully and well? If not, is it because we are poorly informed, or misinformed? Or, perhaps we have lost sight of the goal.

What, after all, are we trying to do with orthoptics? We are attempting to find out in what fashion a pair of eyes are seeing together, if they are; why they are not seeing together, if they aren't; what should be done to make them see together again; and *to do it.* In this last, we have done poorly.

While strabismus *diagnosis,* and orthoptic *diagnosis* have gone forward with our advancing interests in strabismus, orthoptic *therapy* has lagged sadly behind. It is commendable for the technician to test visual acuity, to measure the deviation in the primary position with and without correction, to measure the deviation in the various cardinal positions of gaze, to determine the retinal correspondence under various testing conditions, and to note that suppression is present or absent.

It is more important, however, to overcome amblyopia, to convert abnormal to normal retinal correspondence, to eliminate suppression, to improve fusion, and to increase the fusional amplitude. In doing these things, the technician has rendered a service for which the ophthalmologist is seldom temperamentally fitted and which his busy schedule cannot include.

The orthoptic technician, like the speech therapist, the physiotherapist and the reading instructor, is a teacher. Her only complete justification is her ability to train and retrain a pair of dissociated eyes. Two eyes which have become misaligned and two visions which are no longer fused must be taught to see together and work together again.

This retraining involves several points often overlooked. First, the confidence and cooperation of the patient must be obtained. The manipulation of gadgets by fearful or disinterested children serves no good purpose. Second, the parents must understand the goal toward which the technician is striving and, in general, the steps to be taken toward this goal. More important, the parents must understand, in detail, any home treatment which has been prescribed. Third (really, first), the technician must have a well-considered program of treatment, understand thoroughly the successive steps, and must apply this program intelligently to each individual case. No two individuals or squints are exactly alike. Each must be individually evaluated and treatment prescribed accordingly.

Orthoptic treatment of strabismus is not anatomical, mechanical or motor. Muscles are not being strengthened. Basic binocular alignment is not being changed. Rather, orthoptic treatment is primarily sensory. Two visions are being taught to see as one. Binocular vision is being restored. If, as often happens, alignment improves when binocular vision is restored, so much the better. However, the chief function of orthoptics is to improve binocular vision.

While the assistance the technician may give the ophthalmologist in diagnosis should not be ignored, her primary function should be "treatment." The orthoptic technician is expendable in all phases of her activity except *orthoptic therapy.*

FRANK D. COSTENBADER, M.D.

MESSAGE FROM THE EDITOR

There still are numerous ophthalmologists who seriously doubt the value of orthoptics. Among them are many sincere, outstanding representatives of the specialty. This situation is giving concern to those who believe in orthoptics. When one inquires into the reasons for it, one finds that these men have seen few or no favorable results from orthoptic therapy.

The late Walter B. Lancaster used to say that the ophthalmologist who does not believe in orthoptics does not have the services of a good orthoptist. No doubt in many instances this was and still is correct. The burden of proof lies with the orthoptist. Successfully treated cases are the only acceptable evidence for the effectiveness of any therapy.

The number of certified orthoptists is not large. On each individual member, therefore, devolves the responsibilities of the group as a whole. The certified orthoptists are the shock troops of progress. Their task is not only to treat patients conscientiously and to apply what they have learned, they must also continually strive to perfect older methods and devise new and better ones. Each new patient must be to them a challenge for his own sake as well as for his value as an example for what orthoptics can achieve. To work hard, to attract desirable young workers to the profession and, last but not least, ceaselessly to disseminate information about orthoptics to the medical profession — without overenthusiasm, but also without undue skepticism — these are the duties of the orthoptist.

The orthoptic technician is in an exposed position. She is in the "public eye" of the profession. She alone, through her work, can prove the value of orthoptics.

HERMANN M. BURIAN, M.D.

LOCAL MEETINGS: A SUGGESTION

The founding of the American Orthoptic Council in 1938 created a new era for the American orthoptic technician. The expansion of the organization to include the annual meeting of the American Association of Orthoptic Technicians, the regional meetings, the exhibits, courses and various committees, is tangible evidence that individual participation is mandatory for further success. With the growth and development of an organization, newer members should never feel that their participation is unnecessary.

There are, even now, small groups who have recognized the need for more informal monthly meetings in their individual cities and states. These meetings should offer ample opportunity for the orthoptic technician to discuss case problems, current literature and new theories. The consolidation of procedures in smaller groups would lend itself to further advancement in the department of research. Of course, these meetings may not be feasible in every case but where possible they should be encouraged. Information gathered from these sessions may provide future topics of interest for the regional meetings or for the annual meeting.

NANCY CAPOBIANCO

THE AMERICAN ORTHOPTIC COUNCIL CERTIFICATION EXAMINATIONS

On October 11, 1938, a group of ophthalmologists appointed by the orthoptic committees of the American Academy of Ophthalmology and Otolaryngology, the Section of Ophthalmology of the American Medical Association, and the American Ophthalmological Society, met in Washington, D.C., for the purpose of organizing the American Orthoptic Council. At a second meeting in December 1938, in New York City, regulations governing the training of orthoptic technicians were set up, a code of ethics was devised for orthoptic technicians, and the annual examinations were planned.

In 1941, the American College of Surgeons also became a sponsoring organization with representatives on the American Orthoptic Council. The Council now consists of three representative ophthalmologists from each of the four sponsoring organizations, three technician nonvoting associate members who are elected by the active membership of the Council, and the President of the American Association of Orthoptic Technicians, who is an associate member because of her office.

The first examinations were held in April 1939 in New York City. They were given semiannually in 1939 and 1940, and annually from 1941 to the present. Since the inception of the American Orthoptic Council, there have been 255 successful candidates. Over the past five years there have been 146 candidates, of which number 137 passed.

There are three examinations: the written, the oral and the practical. In the final grading, the following are observed: written, 30 per cent; oral, 20 per cent; and practical, 50 per cent. The written examination is nonassembled and is given throughout the United States and Canada in the offices of ophthalmologists chosen by the American Orthoptic Council as its representatives for the purposes of proctoring. This portion of the examination is designed to indicate the general theoretical background of the candidate's knowledge and training. It is graded independently by two ophthalmologists and one technician without knowledge of the identity of the candidate. The passing of

this examination is important, since on it depends the candidate's eligibility to take the oral and practical examinations.

The oral and practical examinations are assembled and given approximately one month after the written, at the time of the meeting of the American Academy of Ophthalmology and Otolaryngology, the examiners being ophthalmologists and orthoptic technicians assigned by the American Orthoptic Council. The oral examination is designed not only to judge the knowledge of the candidate but to ascertain her reasoning power, thinking process, and personality. It consists of questioning of the individual candidate by two or three ophthalmologists, who grade her independently.

At the practical examination, the candidate is presented with two patients. These patients are strabismic and may be heterophoric or heterotropic, convergent or divergent, accommodative or nonaccommodative, amblyopic or suppressing. They may have abnormal or normal retinal relationships, paralyzed or paretic muscles, or a combination of any of these. The candidate is expected to examine the patient and be able to give an orthoptic diagnosis, an orthoptic prognosis and suggestions for treatment. The examining team consists of one ophthalmologist and one technician, who grade the candidate independently.

Finally, the grades are averaged and the results discussed by the entire examining panel, which recommends to the Council certification of the successful candidates.

The Examining Committee of the American Orthoptic Council has found that the subjects which were most unsatisfactorily understood by the examinees were the accommodation-convergence relationship and the retinal relationships, both normal and abnormal, and suggests that those offices and clinics which undertake the training of orthoptic technicians place greater emphasis on these important subjects than in the past.

DOROTHY R. BAIR

(*Editor's note*: Realizing the importance of carefully qualifying all future technicians, the American Orthoptic Council expects that examinations should be increasingly searching and comprehensive. The technician of the future must have a better basic knowledge on which to develop her practical experience.)

HOME TRAINING TECHNICS

The following exercises were contributed by members of the American Association of Orthoptic Technicians for the 1952 Orthoptic exhibit booth in Chicago.

Some of the suggestions are for increasing fusional range and others are antisuppression exercises. Phorias, and intermittent phoria-tropias are benefited by these exercises.

1. *Red Reading*

The reading material consists of red and black printing or typing. Red kodaloid is held before the preferred eye. If only the preferred eye is looking at the page of red and black printing, only the black words will be visible. If the preferred eye is suppressed, the patient will see both the red and black printing and the page will appear white. However, if fusion is present, the patient will see the red and black printing but the page will appear pink.

2. *Two Pencil N.P.C. Exercise*

The orthoptist holds a pencil horizontally approximately 10 inches in front of the patient's eyes. The patient holds another pencil horizontally and at-

tempts to make the point of that pencil touch the point of the other pencil. As the patient masters this, the orthoptist advances her pencil an inch or so nearer the patient's nose and the exercise is repeated. This continues until the patient can easily touch the point of the pencil at about 30 to 35 mm.

3. *Mirror and Star (Physiologic Diplopia)*

A star (or similar sticker) is applied to the center of a small pocket or hand mirror. As the patient looks at the star, he should see two noses in the reflection. If he fixes on the nose, he should see two stars. This is practiced at different distances from 40 mm. to arm's length and vice versa.

4. *Red Tracing*

Red kodaloid is held before the preferred eye and the patient traces the red outlines, using a red pencil. The orthoptist or the patient's mother may outline in red the picture which is to be used. If the eye without the red kodaloid is suppressing, the picture will not be visible. If fusion is present, the patient will see the outline and the page will appear pink.

5. *Physiologic Diplopia with String*

The patient holds one end of a 3 to 4 foot string to the tip of his nose, the other end being attached to a stationary object. When the patient holds a pencil against the string where the visual axes cross, the string should appear double in the form of an X. As the pencil is moved away from the patient, he should make an effort to see one pencil and two strings. If he sees two pencils or if he sees only one string, he is not fusing.

6. *Mirror Superimposition*

The edge of a small pocket mirror is held on the bridge of the nose in such a position that the patient can look into the mirror with the right eye and see an object to the right or slightly behind him. At the same time his left eye is fixing on an object straight ahead. The mirror can be tilted or rotated so that the mirror image seen by the right eye is superimposed on the image seen with the left eye. This can also be done with the mirror before the left eye. The smaller the images (door knobs, light switches, etc.), the more effective the antisuppression exercises.

ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ORTHOPTIC TECHNICIANS

The eleventh annual meeting of the American Association of Orthoptic Technicians was held at the Palmer House in Chicago on October 13 and 14, 1952.

New Board and Committees

After a report on the Council Meeting by Julia Lancaster, the following boards and committees were established:

1. Association Editorial Board
2. Committee on Instruction
3. Committee on Ethics
4. Committee on Advanced Certification

New Officers

The following officers were elected:

President, Electra Healy

Treasurer, Marie Williams

Representative to Association Council, Dorothy Thompson

Alternate, Ruth Fisher

Vice-President and Secretary to be elected in 1953.

Lancaster Memorial

A memorial to Dr. Lancaster was established as the Walter B. Lancaster Award to be presented each year in the form of a plaque or certificate to a member of the American Association of Orthoptic Technicians who has made an outstanding contribution to the field of orthoptics. The Award may be withheld if, during the year, no particularly outstanding work is brought to the attention of the Award Committee.

Abstract Department

We extend our appreciation to Dr. Derrick Vail, editor, and Dr. F. H. Haessler, abstract editor, of the American Journal of Ophthalmology for permitting us to incorporate a number of foreign abstracts from the Journal. These abstracts are marked by an asterisk and signed with the name of the original reviewer.

We should like to thank the following orthoptic technicians on the Abstract Committee for their assistance in reviewing the literature pertinent to the field of orthoptics:

Maria Borzillo
Mary Ellen Smith Burns
Barbara Cassin
Joan Clavell
Mary Donahue
Evelyn Goldberg
Suzanne Mitchell
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CLASSIFICATION

1. Accommodation
2. Amblyopia
3. Etiology
4. Hypertropia
5. Instruments
6. Management of Strabismus
7. Miotics
8. Miscellaneous
9. Nystagmus
10. Paralysis
11. Refraction
12. Retinal Correspondence
13. Surgery
14. Torsion

1-1

Ripple, Paul H.: *Variation of accommodation in vertical direction of gaze,* Am. J. Ophth., 35:1630-1634 (Nov.) 1952.

The author conducted tests and drew detailed diagrams showing the curve of accommodation in relation to the direction of gaze. He found more accommodation on adduction than on abduction; more accommodation on looking down than on looking up; and still more on looking down and in than on looking up and out. The near point of accommodation should be imagined as a curved surface, concave before the eye, which curves in deeper down and in and flattens up and out. The far point of accommodation demonstrated that a similar phenomenon exists.

Accommodation improved about 25 per cent in the reading position. This factor is important when computing the correct addition for near work. Since most of the methods used to compute the reading addition are done with the eyes straight ahead, this factor is not corrected as such.

A synkinesis with convergence which is in turn affected by vertical gaze is offered as a possible explanation.

2-1

Brock, Frederick W., and Givner, Isadore: *Fixation anomalies in amblyopia,* Arch. Ophth., 47:775-786 (June) 1952.

Whether the true nature of amblyopia is due mainly to cortical suppression or a suppression activity of the retina has by no means been established.

Brock and Givner explain that the presence of amblyopia may be due to a lowered resolving power of the eye. If acuity remains highest in the central fovea, fixation is expected to remain centered. Subnormal vision may be explained by assuming that central acuity is lower than the acuity of the immediately surrounding areas. This, of necessity, would shift fixation to the eccentric retinal region capable of clearest vision.

In cases of severe amblyopia there is a great deal of clinical evidence that fixation may be markedly off center. Brock and Givner describe a method of diagnosing anomalies in amblyopia based on retinal correspondence which requires the ability to interpret the contraocularly induced after-image. This test has proved to be accurate in most cases and is administered quite easily. It is a modification of the after-image test in that only the nonamblyopic eye is exposed to a vertically held light filament placed approximately 4 feet from the patient for a period of 20 seconds while the amblyopic eye remains occluded. After 20 seconds the occlusion is switched to the nonamblyopic eye while the amblyopic eye attempts to maintain fixation

on a black dot located on a test chart. "If the two eyes are binocularly integrated, i.e., if normal correspondence exists, the patient reports that he sees the contraocularly induced after-image as a vertical streak on the test chart via the eye which was not exposed to the light filament." If the streak is located through the center of the black dot, direct fixation ability of that eye may be assumed to exist. If the streak is not through the center of the dot but is seen to the right or left, the distance between the streak and the dot is presumed to show the degree that fixation is eccentric. The after-image test can also be of value to the surgeon in cases of unilateral cataract, i.e., in cases where the cataract is so far-advanced that a search of the fundus is not possible and visual acuity is lowered to finger counting. The test chart must be brought to within a foot or less of the affected eye before the fixation mark may be recognized. If a centered response is obtained, it is almost certain that vision behind the cataract is still good. If, however, fixation is eccentric, the prognosis for usable vision should remain guarded.

The following conclusions, based on the after-image test, were arrived at by the authors on how an amblyopic subject inspects an object of regard when the good eye remains occluded.

1. Amblyopic patients who maintain centered fixation are those with a high degree of anisometropia and amblyopia of rather moderate degree.

2. Amblyopic patients who show eccentric fixation are in the majority and respond to the after-image test as though there was a definite need for eccentric fixation in search for clearer vision.

In Brock and Givner's experiments, evidence is shown that most strabismic patients with uniocular amblyopia retain the ability to transfer the after-image from the exposed eye to the amblyopic eye. In alternating strabismus, however, the tests show that most of these patients are incapable of transferring the after-image.

The authors believe that more critical investigation of central areas in amblyopic patients with eccentric fixation should be attempted.

2-2

Burian, Hermann M., and Watson, C. Wesley: *Cerebral electric response to intermittent photic stimulation in amblyopia ex anopsia: A preliminary report,* Arch. Ophth., 48:137-143 (Aug.) 1952.

Drs. Burian and Watson are of the opinion that the seat of the inhibition in amblyopia ex anopsia lies in the central nervous system rather than in the retinal neurons, as held by some authors. They are inclined to this view since a study of the dark adaptation process in highly amblyopic eyes has indicated a perfectly normal response of the retina.

Working with the idea that electroretinography would permit another means of investigating retinal function in amblyopia ex anopsia, they have recorded simultaneously the electroencephalogram (cerebral potentials), the electroretinograms (retinal potentials), and the photic stimulus itself. This, however, is a preliminary report on the characteristic findings, if there are any, in the electroencephalograms of patients with amblyopia ex anopsia in relation to controlled and adequate stimulation of the retinal elements. Sixty-five normal subjects and twenty-three patients with amblyopia ex anopsia were investigated, with ages varying from 4 to 35 years. The amblyopia varied from an insignificant degree (20/30) to very deep amblyopia of 20/200 with eccentric fixation. Some of the affected persons had had no treatment, while others had been treated by occlusion prior to the test.

The method of testing is described in detail and some electroencephalogram results reproduced.

The authors state, "It has long been known that opening the eyes, in the dark, as well as in the light, results in 'blocking' of the so-called alpha waves." (Alpha rhythm is defined roughly as a rhythm of about 10 cps [8 to 13 cps] occurring in the parieto-occipital areas and usually attenuated by physiologic stimuli.) However, well-defined alpha rhythm may be resumed with eyes open in the light under certain conditions of subjective recall. In view of this the authors have used alternate exposure of eyes in repeated sequence, thus establishing a control in the same subject.

The main findings of the electroencephalogram were:

"1. If the visual acuity of the amblyopic eye was 20/70 or less, alpha activity continued when the amblyopic eye was exposed to stroboscopic light stimulation, whereas it was immediately suppressed on exposure of the normal eye.

2. The rhythmic electric response from the occipital cortex in response to rhythmic illum-

ination of the eyes ('photic driving') was less easily produced in some amblyopic eyes. The driving obtained by illuminating amblyopic eyes was less regular, often occurred momentarily, and was of lower voltage than that obtained by illuminating the normal, fellow eyes."

2-3

*Carlevaro, G. F.: *The prevention and treatment of amblyopia ex anopsia in nursery schools,* Ann. ottal. e clin. ocul., 78:147-155 (Feb.) 1952.

Every nursery school should have a program for detecting and treating amblyopia ex anopsia such as is already in operation in Milan. The good eye should be occluded for at least a month, and the vision of the squinting eye should be stimulated with appropriate exercises. Books with large type should be provided. All of us would benefit if printing were in black on a greenish background instead of on white, as white produces a certain dazzling effect and so weakens the retinal image of the print.

Harry K. Messenger

2-4

Dyer, Dallas, and Bierman, Edward: *Cortical potential changes in suppression amblyopia,* Am. J. Ophth., 35:66-68 (Jan.) 1952.

By use of the electroencephalogram it was found that abnormal brain waves are present in cases with suppression amblyopia. The studies include cases of suppression amblyopia associated with strabismus, alternating strabismus, anisometropia with amblyopia and no strabismus, and paretic strabismus. In cases of suppression, abnormal brain waves appear in some cases before the age of 5 years, in most cases between the ages of 5 and 15 years, and then for some reason disappear in adults.

The results of the studies support the theory of Chavasse that suppression amblyopia is caused at the cortical level. It was found that patients showing abnormal waves appear to have obligatory suppression, and occlusion therapy takes considerable time before visual acuity improves to normal.

2-5

*Hugonnier, R.: *Traitement de l'amblyopie strabique en pratique courante,* Ann. d'ocul., 184:1030-1037 (Nov.) 1951.

The author classifies strabismus with amblyopia as primary amblyopia with secondary strabismus and primary strabismus with secondary amblyopia. The former, or structural, group is usually caused by inflammatory or constitutional diseases which involve the media or perceptive mechanism, and occurs especially in the young. With the structural decrease of vision the urge for binocular single vision becomes less and only one eye fixes. Obviously, re-education is of little or no value. In the second or functional group, amblyopia is usually caused by a constitutional optical or fixation abnormality (phoria-tropia) and one eye gradually deviates. Re-education is frequently justified, especially before the age of 8 years. The author discusses the relative advantages of partial or total occlusion of the fixing eye in accordance with the usually accepted methods.

Chas. A. Bahn

3-1

*Dedimos, P., and Calamandrei, G.: *Sur les troubles de la convergence: étiologie, pathogénie,* Arch. d'opht., 11: 564-570, 1951.

The authors report the results of a study of convergence difficulties seen in private practice. They exclude those cases in which the convergence dysfunction was associated with hyperthyroidism, Parkinson's disease, the Millard-Gubler syndrome, encephalitis lethargica, brain tumors, ocular muscle paralyses, and peripheral facial palsies. They found convergence difficulties in 117 of 6,000 patients; the difficulties occurred very rarely before 16 years of age, and the highest incidence was in men 20 to 40 years of age. They divided their cases into two categories: first, those in which the dysfunction developed slowly and, second, those in which the onset was abrupt. In the first group the patients generally showed nervous irritability and anemia. Errors of refraction were common. In the second group the convergence insufficiency developed either during convalescence from severe systemic infections or after cerebrospinal disturbances. The authors conclude that most cases are toxic in origin. The majority of their patients obtained relief by means of small base in prisms and treatment of their systemic disease. Injections of vitamin B were useful.

P. Thygeson

3-2

Schlossman, Abraham, and Priestley, Bruno S.: *Role of heredity in etiology and treatment of strabismus,* Arch. Ophth., 47:1-20 (Jan.) 1952.

One hundred fifty-eight strabismic patients were observed, and of these 47.5 per cent had a history of two or more members of their families with deviations. Family trees and two or more members of the family were studied. From these studies, statistics and tables were given concerning the heredity of amblyopia, abnormal retinal correspondence, anisometropia in relation to squints, direction of deviation, and relation of surgical results in several members of a family.

Although hyperactivity of the center of convergence, defective fusion faculty, and obvious anatomic malformations were important, they were not major inherited factors except in a small percentage of the families.

The true origin of the strabismus cannot be determined by a simple measurement of the angle of strabismus. "The higher centers, association tracts, nerves and extraocular muscles are the tissues which determine the position of the eyes in the orbits.... If the nerve tissues are involved, it would mean that there is a hereditary defect of the ectoderm, whereas if the muscle, check ligaments, and fascial attachments are affected, it would point to a hereditary defect of the mesoderm."

The studies also concluded the following facts:

1. Anisometropia is a relatively unimportant factor in the etiology of strabismus.

2. Hyperopia alone is not the cause of strabismus.

3. Amblyopia is not inherited and is the result, not the cause, of strabismus.

4. Abnormal retinal correspondence is developmental, not hereditary.

5. Surgical results in one member of a family can be considered a fair guide as to the results surgery will have on other members of the family with the same type of strabismus.

3-3

*Villaseca, A.: *New concepts on the pathogenesis and treatment of strabismus,* Arch. chil. de oftal., 22-23:31-33, 1949.

Binocular vision appears postnatally in a sequence of various visual reflexes. First to appear at the age of 3 weeks is the reflex of monocular fixation, followed by that of conjugate fixation at 4 to 6 months. Shortly thereafter the reflexes of convergence and the corrective reflex of fusion develop. During the first 5 to 7 years of life, these reflexes become conditioned in the cerebrum until they are almost automatic. If this normal development does not occur, the reflexes will never be developed. Therefore, strabismus is considered as a perversion of development of binocular reflexes. Any sensory, motor or central obstacle to development may provoke strabismus. One of three visual adaptations may result: (1) diplopia, (2) suppression, or (3) anomalous retinal correspondence. Treatment is predicated upon an exact diagnosis, which includes examination with the synoptophore. The importance of early treatment is stressed, particularly before the age of 7 years, when binocular vision is completely developed.

James W. Brennan

4-1

Fink, Walter H.: *The vertical component in strabismus,* Arch. Ophth., 47: 292-304 (March) 1952.

The vertical components associated with horizontal deviations in strabismus give great difficulty to patient and physician if improperly managed. When associated with a horizontal deviation, the vertical component is frequently the true imbalance, the horizontal the secondary one. Operation on the horizontal deviation gives a cosmetic result but almost never a functional one. Sometimes a good lateral cosmetic result is lost due to a vertical imbalance unrecognized preoperatively.

The vertical and horizontal imbalance combination was found to be fairly common and statistics are given to support this.

"Diagnosis in the case is based for the most part on procedures which analyze three objective symptoms (abnormal deviation of the eyes, limitation or excess of movement, and the adoption of compensating postural attitudes) and two subjective symptoms (diplopia and false orientation)."

The management of these deviations is broken down into two phases in this discussion: (1) management of vertical deviations and (2) management of combined horizontal and vertical deviations.

Vertical deviations should be corrected as early as possible; the refractive error should be determined and corrected if necessary; ver-

tical prisms should, in certain cases, be prescribed; fusion training should be given in some cases; surgical correction is indicated if other treatments fail or are inadequate.

In the case of combined horizontal and vertical deviations, the vertical deviation should be corrected with prisms before considering treatment of the horizontal; a vertical deviation of 15 prism diopters or more should be treated in the primary operation; if the vertical is greater than the horizontal, the vertical should be operated upon first; when the horizontal is so great that the vertical cannot be well studied, the horizontal is corrected first; if the vertical heterotropia or heterophoria is slight the horizontal is corrected first; when estropia is associated with an overaction of the inferior obliques, correction of the horizontal may correct the overactions; resection of lateral rectus gives fewer overcorrections in these cases; if vertical and horizontal are of high degree they should be corrected at the same operation; the usual procedures for horizontal deviations will give overcorrection and undercorrection when the defect is asociated with vertical imbalance.

4-2

Schlossman, Abraham: *The significance of alternating hypertropia in concomitant strabismus,* Am. J. Ophth., 35:795-801 (June) 1952.

A study of 10 cases of typical alternating hypertropia in patients with horizontal strabismus is presented. The essential features of these cases are:

1. The deviating eye had the higher refractive error in only 2 out of 8 cases. In 3 cases the refractive error was equal in both eyes and in 3 cases the eye with the poorer vision had a smaller refractive error than the eye with the better vision.

2. Often the hypertropia is not measurable with the cover test but is only present in the extreme positions of gaze, resulting from an overaction of the inferior oblique (3 cases). In such cases the hypertropia may become apparent after the esotropia has been decreased in amount through an operative procedure.

3. The chief characteristic of this group is the extreme variability of the measurements. The more the eyes are dissociated by screening, for example, the greater will be the amount of hypertropia uncovered. The esotropia shows a great deal of variability in its measurements both on the same and on different occasions. In fact the patient can show both an esotropia and an exotropia at different examinations.

4. Surgery on the obliques does not correct alternating hypertropia. It may change a monocular hypertropia to an alternating hypertropia or an alternating hypertropia to a monocular hypertropia.

5. Because of the extreme variability of the strabismus, the results of surgery, even on the horizontal muscles, are less predictable than on the average patient with strabismus.

The nature of alternating hypertropia and practical points are discussed.

5-1

Asher, H., and Law, Frank W.: *Stereoscopy and a new stereoscope,* Brit. J. Ophth., 36:225-239 (May) 1952.

This article is concerned with the split-lens stereoscope. The authors show that the simple prism stereoscope allows no control over the relationship between convergence and accommodation and that the demands made upon the patient using the instrument require greater effort than is needed in the course of everyday life. The split-lens stereoscope has been constructed to overcome the errors and limitations of other models and it is possible with this instrument to exercise (1) convergence only, (2) accommodation only, (3) the two in normal relationship or (4) the two in other relationships.

The instrument consists of three parts: the two lenses, the two rails and the two cards which slide along the rails. The two rails are arranged so that the rear ends of the rails are adjustable between positions opposite the lens centers and the position of contact in the midline. The authors outline in detail and with diagrams how the instrument is used.

5-2

*Falkowska, Zoria: *Examination of binocular field of movement on a pane of glass,* Klinika Oczna, 21:19-34, 1951.

This method of examination of the binocular movements of the eyes uses an instrument which consists of a pane of glass 1 meter square which has a Hess chart painted on it. The patient's head is immoblized 50 cm. from the chart; he can fix on any point and the position of the other eye is determined by observing the corneal reflex of a flash light

through the glass. The results are recorded as in the Hess method. The author examined about 200 cases and found:

1. In recent paralytic squints the results correspond to those of blotted double images. 2. In old paralytic cases, binocular fields vary because of a compensating mechanism. It may be impossible to discover the muscle primarily paralyzed but one can determine which one is the weakest. 3. Most concomitant squints show some paralysis. 4. Vertical deviations are frequent, particularly in extreme positions of the eyes. 5. Deformity in the shape of the binocular field of the eye movements points to a dissociation of function of the vertical muscles. The prognosis for binocular vision is poor. 6. Deformity of the field is caused most often by the overaction of the inferior oblique and the inferior rectus, and the underaction of the superior oblique and the superior rectus muscles. 7. In some cases the nonfixing eye has irregularities of movement. Seven cases are described in detail.

Sylvan Brandon

5-3

Harding, Glen F.: *Photography of strabismus patients using the polaroid camera,* Am. J. Ophth., 35:1353-1354 (Sept.) 1952.

In this article Dr. Harding tells how he has eliminated many photographic problems with strabismus patients. One minute after exposure he has a finished print by using a Land Polaroid camera. The problem of movement, position, focus, poor lighting, reflexes on spectacle lenses and mechanical failure can be readily corrected by additional exposures. He designed a wooden paddle with a cross-piece device for convenience in taking pictures in the cardinal positions.

The cost is approximately $160 for the complete outfit, and the cost of a print is less than 25 cents. For record purposes of the diagnosis, refractive findings and surgical procedures, the backs of the prints may be used.

5-4

Steckler, M. L.: *The eye exercise stick,* Am. J. Ophth., 35:1502-1503 (Oct.) 1952.

This is an interest-holding, inexpensive home exercise device which Dr. Steckler finds most beneficial for patients with conditions such as "convergence insufficiency, fusion deficiency, fusion-convergence insufficiency, inertia of accommodation, phorias and so on." It consists of a pocket size stick with three sizes of the letter "E" and a small vertical line at the top. The patient repeatedly draws the stick toward his nose and at the same time attempts to keep the letter clear, starting from the largest and progressing to the smallest "E" and then to the small vertical line. This exercise should be carried out for a period of six to eight weeks.

5-5

Teschner, Bernard M.: *Simple aid for fusion,* Am. J. Ophth., 35:1690-1691 (Nov.) 1952.

Dr. Teschner has found the Viewmaster a useful aid in (1) testing fusion and stereopsis, (2) home fusion training, (3) marked monocular dominance and (4) amblyopia in accommodative squint cases which are orthophoric with correction. It is necessary to mark a small vertical line on one of the pictures and a carefully marked horizontal line on the other so as to form a cross on fusion. Children do not object to this home training because the selection of targets is interesting.

6-1

Braley, Alson E.: *Management of convergent strabismus esotropia,* J. Iowa M. Soc., 42:106-110 (March) 1952.

The various aspects in the management of esotropia are covered briefly but concisely.

For the complete examination it is necesary to obtain accurate information concerning visual acuity, rotations, measurements of deviation, refraction, ophthalmoscopy, correspondence, grade of fusion and angle kappa. The importance of a careful history is stressed.

A complete functional result should be attempted, even if it cannot always be attained. Dr. Braley tries to obtain a complete functional result without glasses by the age of fifteen. His next criterion is good visual acuity in both eyes even though functional result is not possible. His last objective is to try to get a good cosmetic position during the teen and young adult life.

A careful correction of the refractive error is important. The author prefers to give the cycloplegic in the office. His method of cycloplegia is as follows: one drop of 0.5 per cent pontocaine is instilled, followed in one or two minutes by one drop of 5 per cent homat-

ropine in 1:5000 zephiran. This is followed in two or three minutes by a drop of paredrine and then a drop of 1 per cent atropine or ⅛ per cent scopolamine solution. Cycloplegia is usually good in 40 to 75 minutes.

In the treatment of amblyopia, total and constant occlusion of the good eye must be carried out. The occluded eye should be watched carefully for visual loss.

Dr. Braley prefers to treat anomalous correspondence by first setting the eyes straight after vision is equal and following this with vigorous "macular massage" and occlusion.

The author feels that the best method for treating esotropia is to place the eyes in the physiologic position and that this should be done as soon as the child has been given the fundamentals of superimposition and has nearly equal vision in each eye. He prefers to set the eyes straight with one operation and therefore operates on two or more muscles at one time. He discusses his choice for the type and amount of surgery to be done according to (1) the age of the patient, (2) the difference between the esotropia with and without glasses, (3) monocular and binocular rotations and (4) the appearance of the esotropia under anesthesia.

6-2

Douglas, A. A.: *Value of orthoptics in the treatment of squint,* Brit. J. Ophth., 36:169-201 (April) 1952.

The author traces the growth of orthoptics from the mid-nineteenth century to the present day and emphasizes the contributions made by Emile Louis Javal in this field.

The most significant development in the last thirty years has been the rise of the orthoptic technician. The author says that the orthoptic department is here to stay in some form or other. After discussing binocular vision and the views laid down by Javal, Worth, Chavasse and others, he indicates the diversity of opinions on the value of orthoptic training. He notes the absence of any published results of controlled experiments upon which accurate evaluation can be made but points out the difficulties encountered in the preparation of such experiments. He mentions (1) the necessity to study a very large series of cases, (2) the difficulties of determining the standard of morbidity, (3) the difficulties of deciding on the standards of cure, and (4) the time that must be devoted to following up the cases, a survey that might cover 14 years.

The author criticizes past publications and says that none of them provide proof of the value of orthoptics.

He presents a study of two groups of cases of comitant squint. He discusses his results in detail. In accommodative squint the author believes it is erroneous to say that the apparent cure with glasses is never satisfactory when the patients are denied orthoptic training. He finds after a study of 37 cases the advantages of orthoptic training are not obvious. The author discusses the improvement in binocular functions noted in cases of convergent squint with a fixed element, after operative intervention and orthoptics. He questions the part played by training in this improvement and feels that the change in the position of the eyes is the important factor, although he concedes that the period of flux following surgery may be used by the orthoptist to reawaken dormant functions.

The author shows that in a series of 34 cases of anomalous correspondence treated before or without operation, only three reacted normally. He says that data of ocular position play a more important part in the mechanism of anomalous correspondence than any modified retinal correlation. Therefore, in his opinion, it is illogical to attempt to reawaken retinal correspondence by training while the important abnormal positional relationship, which is the cause of the anomalous reaction, remains undisturbed.

The author discusses the effect of the age of onset on the results of operation. He presents a study of 214 cases operated on by him from 1946 to 1949. Of these the average age was 7.7 years and 55 cases achieved single binocular vision, while 159 failed to do so. The results show that the proportion of patients with single binocular vision rises from 2 per cent for the group in which the age of onset was the first year to 100 per cent for the group with onset between 5 and 6 years. He noted that the age at which operation was performed was of little consequence.

In conclusion, the author notes the prolonged training of a large number of cases without apparent improvement. He shows that orthoptic training in a large sense is experimental and regrets that the work is not more exact, that inquiries into specific problems are not made and that controls are not introduced.

He draws a comparison between Javal's method of treatment and that of the present day, with regard to the time devoted to individual treatments and to selection of cases.

The author explains the lack of success with training by the following facts:

1. Nature forbids its use during the formative years of early childhood (1 to 5 years). The ability of the nervous system recedes during this period to such an extent that any real facilitation of the binocular reflexes is hardly possible.

2. The constant repetition of meaningless stimuli inseparable from orthoptic training leads to inhibition, which rapidly spreads to the rest of the cortex. The effort to prevent this is not within the power of small children.

The author reiterates the importance of the part played by surgery in those cases where improvement in binocular functions postoperatively were found.

He feels the contribution made by orthoptics, mainly as a result of Javal's work, to our knowledge and understanding of the complicated binocular reactions in squint cannot be doubted. He says the use of orthoptics in diagnosis is not in dispute. He emphasizes the need to balance the reward likely to be obtained by the patient as a result of orthoptic training against the trouble, danger and expense involved. He is not convinced that the effort expended to obtain single binocular vision in some cases is justified and he points out that cases must be judged individually.

6-3

Feldman, Jacob B.: *Utilization of psychology and education in the management of the orthoptic patient,* Eye, Ear, Nose & Throat Monthly, 31:89-95 (Feb.) 1952.

Orthoptics should be done on an educational basis, providing material that is interesting and stimulating to each child according to his ability. All patients suitable for orthoptic training are accepted after a form letter sent to the school is completed, giving the medical, psychologic and scholastic aptitude of the child. When the child returns to the doctor, he is examined by a psychologist. The psychologic report is analyzed and a plan for teaching is prepared for the individual case. If an involved psychologic problem is present or psychologic treatment is indicated, the patient is referred to a consultant.

After evaluating the makeup of the child, the problems for the orthoptist are as follows:

1. What should the goal be for this individual child?
2. How is the work to be organized and at what rate is it to progress?
3. How is rapport to be established?
4. How can parental cooperation be obtained?
5. What are the obstacles in the path of progress for this particular child?

Orthoptic treatment given properly can be as beneficial to the dull or average child as to the intelligent child.

6-4

Gardner, Harold O.: *Orthoptics,* J. Iowa M. Soc., 41:491-495 (Dec.) 1951.

If all nonsurgical treatment of strabismus is considered as a part of orthoptics, its objectives are: (1) the diagnosis, prevention and cure of suppression and amblyopia, (2) the diagnosis, prevention and cure of anomalous correspondence and (3) the teaching of binocular visual habits by the development of fusion in all grades.

Practically all anomalies of binocular vision in convergent strabismus develop as a means of overcoming diplopia. Diplopia cannot be tolerated for long, and either suppression or anomalous correspondence develops.

Suppression is a "conditioned reflex, the conditioning stimulus being in the use of the other eye." If neglected, this inhibition of one eye gradually becomes fixed, and amblyopia follows. Prevention of amblyopia should begin at the earliest possible stage even though the child is considered too young for other treatment. The treatment of amblyopia is complete and constant occlusion. Various games and exercises such as coloring, bead stringing and puzzles may be utilized to stimulate the dormant macula.

The visual acuity that may be developed or recovered depends upon the age at which the squint began and the length of time before treatment was started. Usually the later in life the suppression began and the shorter the length of time it was allowed to go untreated, the better the prognosis.

The diagnosis of anomalous correspondence is made by means of (1) the diplopia test, (2) the after-image test and (3) the major amblyoscope. To eradicate this anomaly, total occlusion of the fixing eye is carried out. Active treatment used successfully by many orthoptists is "macular massage." Those cases which do not respond to this form of therapy should be operated upon and "massage" tried again.

To have normal binocular vision three requirements must be met: (1) the coordination of all extraocular and some intraocular muscles in such a manner that images are brought to focus on the maculas, (2) the fusion of these two images clearly and distinctly into one and (3) the projection of this image into its proper spatial location.

To obtain normal binocular vision, fusion with amplitude and stereopsis is the goal to be strived for in the treatment of squint. Most observers feel that stereopsis cannot be taught but that when a child does have stereopsis, it can be developed so that discrimination of depth differences will be more acute.

In developing fusion, the stereoscope, cheiroscope and other instruments may be used, all of which are on the same principle as the major amblyoscope.

The author closes with a quotation from Dr. Lancaster: "With the major amblyoscope the orthoptic technician has the situation firmly under control. There are no extraneous stimuli entering the situation. The technician can control the lights and movements of the instrument and can control the stimulus by the choice of targets, so that the patient is almost forced to make a correct response. Once he makes the response, he is praised for it, then encouraged to repeat it. Thus the patient learns. This is orthoptics."

6-5

Gill, Elbyrne G.: *Management of crossed eyes,* Eye, Ear, Nose & Throat Monthly, 31:597-599 (Nov.) 1952.

Each patient presents a different problem which must be evaluated before treatment can be prescribed. The predisposing causes and the classification of the deviation are listed. Atropinization of the eyes, occlusion of the fixing eye, correction of the refractive error should be thoroughly carried out before the third year of life. Orthoptic training is done under the following conditions: age must be over 4 years, I.Q. must be good, attendance must be regular, vision in poorer eye should be at least 20/40, retinal correspondence must be normal, paralytic cases must be eliminated, marked vertical deviation must be eliminated, and the patient must show a good capacity for binocular vision on the synoptophore.

Treatment for the strabismus must be begun as soon as the squint is definitely manifested, irrespective of age.

Three cardinal principles are followed in selecting individual muscles for surgery: (1) to weaken a strong muscle, (2) to strengthen a weak muscle and (3) to confine all surgery to the particular field involved and not to disturb normal fields.

6-6

Lancaster, Julia E.: *Progress in orthoptics,* Sight-Saving Rev., 21:211-214 (Winter) 1951.

The author has presented a short history of the development of orthoptics as an adjunct to the field of ophthalmology. The formation of the American Orthoptic Council, its membership, and its function are described.

The motor and sensory aspects of fusion are discussed. Motor fusion makes it possible for the two foveas to receive fusible images. Sensory fusion is the interpretation of these images by the brain as a single image. Motor fusion skills are "fixation, versions, vergences, accommodation, and accommodation-convergence balance." While these motor skills are being learned, the child also finds it necessary to respond to sensory stimuli. If motor progress is impaired at any stage, sensory progress is forced to make one or more of several abnormal adaptations: "suppression, anomalous correspondence or tolerance of diplopia."

The purpose of orthoptics is to help the patient develop normal fusion habits for casual seeing. Motor fusion and sensory fusion are inseparable in the visual act, and the author points out that treatment must be directed toward both functions. Orthoptic treatment of motor fusion is mainly objective and consists of the development of (1) foveal fixation in both eyes, (2) normal versions, (3) normal vergences and (4) normal accommodation-convergence balance. The evaluation of the sensory fusion status is dependent entirely upon the overt responses of the patient.

The author points out that each of Worth's grades of fusion requires both motor and sensory responses. The first grade of fusion is simultaneous perception and requires fixation (motor control) and normal sensory adaptation (normal correspondence and no suppression). The second grade of fusion is fusion with amplitude and requires vergence (motor control) and recognition of diplopia (sensory perception) when vergence fails. The third grade of fusion requires stable binocular fixation and stable sensory perception to allow evaluation of the stereogram. Miss Lancaster indicates how the patient's responses determine

the type of treatment needed, and how treatment can be made more efficient if each step of motor fusion is accompanied by the simultaneous development of sensory perceptions.

In conclusion the author calls attention to the need for further research in orthoptics.

6-7

*Portmann, U. P., and Dufour, M.: *Indications et contre-indications données par l'orthoptique dans le traitement du strabisme convergent concomitant,* Ophthalmologica, 123:294-303 (April-May) 1952.

This report from the eye clinic of the University of Lausanne is essentially a statistical study of the value of orthoptics in the treatment of convergent concomitant strabismus with no accommodative component or only a slight one. The guiding principles were those developed and formulated by Chavasse. The results of surgery plus orthoptics were, on the whole, better than those of surgery alone. Attempts at normalization of retinal correspondence (by orthoptics) are not always indicated, especially not in adults whose strabismus started at a very early age and in whom one must suspect that the binocular reflexes developed only partially and are probably extinct. Orthoptics in these cases may give rise to very annoying and persistent diplopia. In the usual childhood form of esotropia the authors stress the value of the earliest possible recognition of the strabismus and the value of early inception of treatment.

Peter C. Kronfeld

6-8

Schlossman, Abraham, and Parkhill, Dorothy: *A simple approach to orthoptics,* Eye, Ear, Nose & Throat Monthly, 31:469-475 (Sept.) 1952.

The purpose of orthoptics is to strengthen the fusion faculty. If cooperation between the two eyes is inadequate or nonexistent, it is often impossible to obtain any results by orthoptics.

Orthoptic training is most effective in those patients with intermittent or periodic heterotropia in whom its use may effect a cure or enhance the results of surgery. The treatment of heterotropia falls into two classes, amblyopia and antisuppression exercises. A list of exercises recommended are described in detail.

7-1

Abraham, Samuel V.: *The use of miotics in the treatment of nonparalytic convergent strabismus: A progress report,* Am. J. Ophth., 35:1191-1196 (Aug.) 1952.

This article gives step-by-step accounts of the use of miotics, particularly Floropryl, in the treatment of nonparalytic convergent strabismus and in postponing or avoiding the use of glasses in the cases of hyperopia. It was noted that cases falling in the periodic-isometropic category were the most benefited.

By using a miotic, the accommodation becomes excessive to the amount of convergence, thereby allowing a proportional ratio of accommodation-convergence necessary for the binocular situation to become established. The application of the miotic was generally continued for a two-year period in the majority of cases, even after the eyes had straightened, to prevent a recurrence of the strabismus. These cases require good fusional amplitude and should be followed until they have reached the age of 8 years. Special emphasis was made of the importance of equal visual acuity in the treatment.

Dr. Abraham also found miotics of definite value in the treatment of amblyopia where unsuspected lack of accommodation may be present.

8-1

*Barlow, H. B.: *Eye movements during fixation,* J. Physiol., 116:290-306 (March) 1952.

The movements of the human eye were measured by photographing a droplet of mercury placed on the cornea. The usual pattern of saccadic movements separated by fixational pauses was found. When the eye was fixed on a given point, the individual fixation positions were found to be scattered about 5 minutes of arc. Selected fixational pauses showed very little movement. The results were checked by the use of afterimages.

Irwin E. Gaynon

8-2

Burian, Hermann M.: *Strabismus, review of the literature,* Arch. Ophth., 48:90-107 (July) 1952.

In a comprehensive review of the literature on strabismus which has appeared in the last

year, Dr. Burian underscores the significant contribution of Dr. Keiner's book, "New Viewpoints on the Origin of Squint."

Dr. Keiner, working from the records of 656 patients, 573 of which were under the age of 6 years, paid close attention to, among other things, the age of onset. Due to the fact that a vast majority of the cases showed a very early age of onset, Keiner was led to important positive and negative conclusions.

On the positive side, it suggested that all children are born as potential squinters and that this universal predisposition is offset in the course of normal development in approximately the first 18 months of life. According to him the process may be interfered with secondarily by endogenous or exogenous factors from the end of the first year onward. Therefore, Keiner distinguishes two groups of patients: those who are primarily affected with strabismus at the end of the first year, and those in whom the condition becomes manifest secondarily.

Negatively, the early onset of strabismus implied that refractive errors, absence of sensory fusion, or abnormalities in the convergence function could not be primarily responsible for the strabismus. Also, he could not accept the theory of a mechanical (muscular) or of a paralytic origin of the strabismus as advocated by some other authors. He believes the causative factor to be a disturbance of the normal development of the optomotor reflexes and that in the course of postnatal development these reflexes determine the relative position of the eyes. Consequently, the abnormal position of the eyes in convergent strabismus is the consequence of an abnormal development of the optomotor reflexes—a predominance of the monocular adduction reflexes over those for conjugate movements and abduction.

Some observations are explained in more detail. Through his observations, along with consideration of the normal development of the optomotor reflex, Keiner was led to the theoretically important conclusion that Hering's law does not apply to the newborn or to concomitant strabismus and consequently that disturbance of the sensory cooperation and amblyopia must be thought of as a result of the strabismus rather than as its cause. Keiner thinks that a delay in the process of myelination may be the answer to why only a certain percentage of people present a manifest strabismus. In turn, the cause of the retardation of myelination may be found in a disturbance in the fetal and postnatal endocrine system of the infant.

In regarding the refractive error of patients with esotropia, Scobee and Keiner found that the hypermetropia was usually between 1.5 and 4 diopters and agree that anisometropia is not frequent enough to be considered important in the causation of strabismus. Also it is admitted that heredity is an important factor. Keiner considers strabismus hereditary if the condition is present in one or both parents or one or both grandparents. Similar views are held by Scobee, Schlossman and Priestley. Dahlberg and Nordlöw considered it probable that the condition may result from different mutant genes so that different families will exhibit different types of inheritance.

Sensory phenomena. In dealing with amblyopia ex anopsia, Beitti, through subconjunctival injection of oxygen, noted a reduction in size of the central and paracentral scotomas and in the size of the enlarged blind spot. This led him to believe that the process of suppression in squint is not purely cortical but also involves the retina. Keiner is in opposition to this in that he believes that suppression in amblyopia is a phenomena of the central nervous system because the findings of the electroretinograph were normal in eyes with amblyopia ex anopsia.

In another aspect Posner and Schlossman believe that peripheral vision is the more primitive function, therefore peripheral fusion is more stable and may be used by the patient to restore binocular single vision with or without the aid of orthoptics or surgery. Keiner in similar views is emphatic in the need of first establishing peripheral fusion in the training of squinters.

Nonsurgical treatment. Dr. Burian underscores the rich contribution to orthoptics by Julia E. Lancaster through her book, "A Manual of Orthoptics" and outlines some of its main points. Lyle, in a discussion, also renders a distinct service in counteracting the idea that orthoptic training in itself can effect a cure in a large percentage of cases of strabismus of all types. Burian and Gardner are in agreement, too, that orthoptics should not be thought of as a means of straightening crossed eyes. Burian emphasizes, "Orthoptics can only redirect and reorient the proper use of the two eyes, and it only incidently corrects the relative position of the eyes through normalization of the innervational conditions." Also, "Orthoptic treatment should not, however, be used routinely for every type of strabismus without thorough consideration of the medical, social, and educational indications and contraindications."

Dr. Burian reviews the literature on surgical procedures in strabismus quite thoroughly.

8-3

*Franceschetti, A.: *Le strabisme concomitant aigu,* Ophthalmologica, 123: 219-226 (April-May) 1952.

The author reports five cases of convergent strabismus characterized by the following features: 1. sudden onset of esotropia and diplopia, 2. a high degree of constancy of the angle of squint in the various positions of gaze, 3. no tangible signs of muscular palsy or of spasm of convergence, 4. excellent fusion, 5. no significant refractive error, 6. probably a pre-existing exophoria and 7. excellent cosmetic and functional results achieved by small surgical interventions.

The mechanism of this form of esotropia is not definitely established, but is probably not paralytic. The author favors the idea of a temporary impairment, by systemic disease, physical or psychologic trauma or unusual physical stress, of the fusion or divergence function followed by an acute escape reaction, namely esotropia. Prompt surgical treatment is advocated if conservative measures, including orthoptics, do not bring about a cure within one or two months.

Peter C. Kronfeld

8-4

Keiner, G.B.J.: *Some results of early treatment of squint,* Ophthalmologica, (Basel) 124:367-370 (Dec.) 1952.

The speaker discussed the results of early treatment of squint, dealing exclusively with those attainable by simple conservative measures. Only cases of strabismus convergence were considered.

The earlier the treatment and the shorter the time for which the abnormal stimuli have acted, the more rapidly is one able to open up and pave the way for the normal development of the reflexes.

When the child comes under treatment it is necessary to abolish abnormal reactions which have already developed. Thus the way is left clear for reflexes which belong to the normal development schema, according to the child's age, and to promote and stimulate the initiation or development of these reflexes.

The importance of continuous amblyopia treatment is stressed, since intermittent covering is generally useless and much more unpleasant for the child. If in this way normal position of the eyes and satisfactory vision can be achieved, it may, with young children, be taken as certain that with a normal reflex mechanism, binocular vision will also develop in the natural way.

If the squint is still present following occlusion for amblyopia, some form of orthoptic exercise is prescribed.

The author regards a squint as cured when, in addition to a correct position of the eyes, binocular vision has been achieved. Operative correction of the position of the eyes is still indispensable in some cases, especially the older cases.

8-5

*Nordlöw, W.: *Spontaneous changes in refraction and angle of squint, together with the state of retinal correspondence and visual acuity in concomitant convergent strabismus during the years of growth,* Acta ophth., 29:383-421, 1951.

The material for this study consisted of 142 cases of convergent concomitant squint collected at random, and followed for an average of 10.2 years with an average of 7.9 control examinations. The data thus obtained are tabulated. The author believes that the primary static angle of squint is due to mechanical conditions, and changes in the angle are a sign of changes in the mechanically induced positions of the eyes. The data show that the primary static angle of constant convergent strabismus does not change until the age of 7 years, but from then until 15 or 16 years of age it increases in 12.5 per cent of cases, and decreases in 41.7 per cent. Postoperative divergence developing rapidly after an operation for strabismus is attributed to faulty surgery. If the axes of the eyes are made parallel surgically before the age of 7 years without achieving binocular single vision a certain percentage will develop divergence during the years of growth. The data indicate that a change will occur in 40 per cent of cases (convergence in 10 per cent, and divergence in 30). In addition, divergence of 11 to 20 degrees is apt to appear in every tenth case when the patient reaches 15 or 16 years of age. If binocular vision with some amplitude of fusion is developed after surgery the prognosis is better. The results of orthoptic training and correction of refractive errors are poor from a cosmetic and functional standpoint. The goal of treatment should be

to abolish the static angle of squint at an early age. The author is not convinced that the reports in the literature of the reduction of the static angle of squint or orthoptic training are justified. Early surgery in 22 young children with convergent squint, which began in the second six months of life was followed by binocular single vision in 91 per cent.

Ray K. Daily

8-6

*Scullica, Francesco: *The limits of stereoscopic fusion,* Ann. ottal. e clin. ocul., 77:303-322 (Aug.) 1951.

Scullica measured the limits of stereoscopic fusion in ten subjects by experiments with Holmes's stereoscope, with Maggiore's mirror stereoscope, and without any stereoscope (by dissociation of accommodation and convergence). For stereograms he employed the familiar pair of two eccentric circles, and determined the limits of fusion by noting how far the inner circle of each pair could be displaced in various directions while stereopsis was maintained. He concludes that there are no absolute limits within which stereoscopic fusion is possible. The limits are imposed by optical and anatomicophysiologic factors (visual acuity, region of the retina concerned, interpupillary distance) which are more or less constant for all subjects at all times, and by physiologic factors (as nystagmiform movements of the eyes, suppression, attention, stereoscopic training) which vary from subject to subject and in the same subject under different conditions. No sharp boundary can be drawn between the optical and the psychologic limits. If the binocular parallactic angle is equal to or is less than the minimum visual angle of one minute, the optical factors are chiefly operative, but if the minimal visual angle is exceeded, fusion generally does not occur without intervention of psychologic factors. The triad playing the principal role in determining the limits of stereoscopic fusion are the unvarying stereoscopic parallax and the variable attention and ocular movements.

Harry K. Messenger

8-7

Stillerman, Manuel L., Gibbs, Erna L., and Perlstein, Meyer A.: *Electroencephalographic changes in strabismus,* Am. J. Ophth., 35:54-62 (May) 1952.

The authors conducted a clinical study evaluating the relationship between electroencephalographic studies and types of strabismus, as well as other eye disorders. The 1,345 cases in the study had an age range of 2 to 16 years.

The electroencephalograms were taken with the patients awake and asleep, since sleep brings the higher proportion of abnormalities.

The authors summarize the findings as follows:

"1. A clinical correlation between electroencephalographic studies and strabismus, as well as a group of miscellaneous eye disorders, has been made in 1,345 children under the age of 16 years.

2. In children with organic brain disease causing cerebral palsy, electroencephalographic foci in the occipital region occurred almost twice as frequently in the presence of abnormal eye findings. The nature of this relationship prevailed whether or not seizures were present.

3. In 605 cerebral palsy cases with seizures and ocular pathologic findings, predominantly strabismus, electroencephalographic foci involving the occipital region were six times more common than all other foci combined.

4. Of 89 normal children with strabismus, 20.2 per cent had occipital lead abnormalities in their electroencephalograms. In the control group of 180 normal children without strabismus or other ocular pathology only 0.5 per cent had occipital lead abnormalities in their electroencephalograms.

5. Occipital abnormalities in the electroencephalogram occurred twice as frequently in the normal children with exotropia as in esotropia (32 per cent to 17 per cent). When the occipital abnormality consisted of spikes, the incidence in normal children with exotropia was approximately four times that with esotropia (22 per cent to 5 per cent).

6. No abnormal electroencephalograms were found in the group of normal children with miscellaneous ocular pathologic conditions. It is probable that an ocular pathologic process limited to the peripheral organ does not affect electroencephalographic patterns.

7. No correlation was demonstrated between abnormal electroencephalographic findings and fusion, the laterality of the deviation in strabismus, and retinal correspondence. The equivocal relationship between electroencephalographic disturbances and amblyopia ex anopsia is discussed."

8-8

*Verdaguer, J.: *Thoughts on phorias,* Arch. chil. de oftal., 22-23:27-30, 1949.

It is incorrect to associate heterophoria with the ocular muscle apparatus itself; it should rather be thought of with the supernuclear centers. Of the latter, the centers of convergence and divergence are the most important. Movements of fusion, in which the images of an external object falling upon a parafoveal area are transferred to the maculas, are executed with mathematical precision. A slight error in position produces diplopia. Movements which produce binocular vision are not purely reflex, for the cortex plays a role. The term "automatic" is preferred, recognizing the influence of the psychovisual centers of the occipital cortex. Auditory and labyrinthine controls play a role in fusion also. Imperfect movements of fixation are the basis of heterophoria. For diagnosis, the cover test, Maddox rod, near point of convergence, and prism vergence measurements are necessary.

Headache, not relieved by correction of refractive errors and unexplained by other causes, is the most prominent symptom in the patient wih heterophoria. The majority of patients have a neurotic character, making evaluation somewhat difficult. A therapeutic test is used in which one eye is occluded for ten days. Relief of symptoms is considered indicative of the association of the heterophoria and the symptoms. Orthoptic training is highly successful in treating heterophoria. Results are best in convergence insufficiency, the most common of all anomalies of motility. Prism exercises are the only orthoptic therapy discussed.

James W. Brennan

9-1

*Murry, L.: *Nystagmus associated with strabismus,* Rassegna ital. d'ottal., 20: 329-330 (Sept.-Oct.) 1951.

Twelve children with strabismus which developed in the first years of life or immediately after an acute febrile episode were studied. Complete ophthalmologic and neurologic examinations were made as well as otologic studies of vestibular function. When a unidirectional nystagmus can be induced in a patient with strabismus, a central vestibular lesion is probable. When the muscle tone is low after influenza the ocular muscles are also affected and an alternating strabismus, partly vestibular in origin, may arise which later becomes unilateral.

Eugene M. Blake

10-1

Blumenthal, Helmut, and Savitt, Louis: *Paralysis of disjunctive ocular movements,* Eye, Ear, Nose and Throat Monthly, 31:141-143 (March) 1952.

A case report of convergence palsy is presented with all the typical findings.

The etiology of convergence palsy is inconclusive. The syndrome is manifested by a sudden onset of crossed diplopia for the near point with singular binocular vision for distance, either eye showing no limitation of movement in any of the nine cardinal directions, and normal pupillary reaction to light but usually not to accommodation.

The prism test is helpful to differentiate between true convergence palsy and functional convergence weakness. A prism placed base out before one or both eyes to check prism adducting power will show that the eyes will move in back of the prisms and register the presence of convergence, while in direct paralysis, diplopia will increase.

The prognosis and treatment are generally poor. Orthoptic exercises seem to be valueless; occlusion of one eye is the only treatment until the condition becomes stable.

10-2

*Rama, G.: *Horizontal divergence due to paralysis of convergence,* Rassegna ital. d'ottal., 20:315 (Sept.-Oct.) 1951.

The author presents a case of paralysis of convergence with horizontal divergence of organic nature in which surgical correction had been attempted by bilateral medial recti advancement. Besides correction of the divergence and relative diplopia for distance there was partial restoration of convergence. The result is interpreted as due to the creation of an esophoria which was compensated and regulated by the function of active divergence.

Eugene M. Blake

11-1

de Ocampo, Geminiano: *Di-isopropyl fluorophosphate (DFP) in cycloplegic refraction,* Am. J. Ophth., 35:1484-1488 (Oct.) 1952.

This is a study of cycloplegic refractions done on 55 Filipinos in an attempt to lessen the long-lasting disability of cycloplegics, especially atropine.

One per cent atropine sulfate ointment was administered at intervals, depending on the age of the patient. The consequent loss of accommodation was measured on the cilometer and the size of the pupil measured in millimeters before refraction. Upon completion of

refraction, one drop of pontocaine or cocaine was administered before the DFP (di-isopropyl fluorophosphate) to eliminate any irritation. One hour later the accommodation and the size of the pupil were again measured and, if necessary, another drop of DFP was given. The majority of cases required two drops of DFP at one hour intervals. Within 2 to 4 hours the accommodation returned to 3 or more diopters and the pupil constricted to 3 mm., abolishing mydriatic glare. The visual disability of cycloplegia remains 7 to 14 days longer.

12-1

Burian, Hermann M., and Capobianco, Nancy M.: *Monocular diplopia (binocular triplopia) in concomitant strabismus,* Arch. Ophth., 47:23-30 (Jan.) 1952.

"Monocular diplopia ... consists essentially of the simultaneous localization of a single physical stimulus, reaching one eye, in two different subjective visual directions, one normal and one abnormal." This condition occurs only in patients with anomalous retinal correspondence.

Monocular diplopia is rare as a spontaneous thing but can be elicited by artificial means. A brief description of Walraven's technic for treatment of anomalous retinal correspondence, which uses monocular diplopia, was presented, and a case described.

Monocular diplopia is not the result of two points of the retina being stimulated, but is the result of the normal and abnormal subjective localization of one point. This should be clearly understood.

A neurophysiologic explanation of anomalous retinal correspondence and monocular diplopia was given.

12-2

*Kretzschmar, S. J.: *A propos de la fausse correspondence rétinienne,* Ophthalmologica, 123:343-348 (April-May) 1952.

The phenomenon of anomalous retinal correspondence in general and the location of the anomalous corresponding points in particular had previously been investigated only within a narrow horizontal strip of the binocular visual space. To determine the distribution, or rather redistribution, of corresponding points over the entire binocular space was the principal object of the present study. The experimental setup worked out for this purpose by the author was essentially that of haploscopy. Two targets, identical in shape but produced by beams of light polarized at right angles to each other, were projected onto a special, polarization-preserving screen by means of two projectors and viewed by the examinee through polaroid filters. Each target, thereby, was visible to one eye only. In patients with heterotropia and anomalous correspondence the subjective sensation of coincidence of the two targets was created if they were presented at the subjective angle of squint. The angle actually subtended by the targets on the screen could be measured accurately. With this method Kretzschmar found the subjective angle to remain practically the same over the entire binocular visual space. Since the objective angle of squint varied very litle during such tests, the constancy of the subjective angle proved that the reallocation of local signs had occurred (in the same manner) not only in the area in and around the macula of the fixing eye and the pseudomacula of the deviating eye, but practically all over the binocular visual space.

Whenever the targets were presented in a position corresponding to the subjective angle one of three phenomena occurred: (1) smooth superimposition of the two targets, (2) a jump of the target offered to the deviating eye and (3) exclusion of the target offered to the deviating eye. The jump phenomenon occurred in a very regular manner, only in the horizontal direction and irrespective of whether the subjective angle was approached from the right or left.

If several pairs of targets were offered simultaneously, the same anomalous correspondence and the same phenomena at the subjective angle occurred in most cases. Kretzschmar, however, discovered a few exceptional cases in which the anomaly of correspondence varied for differently shaped targets. The explanation of this phenomenon has to be sought in the realm of psychophysiology.

Peter C. Kronfeld

12-3

Pascal, Joseph I.: *The two phases of abnormal retinal correspondence,* Am. J. Ophth., 35:1204-1206 (Aug.) 1952.

Anyone having worked with abnormal retinal correspondence is well aware that there are degrees of abnormal retinal correspond-

ence, and Dr. Pascal has set about to classify these degrees as an aid in determining how fixed an abnormal retinal correspondence may be and to guide in determining the procedure to follow regarding a strabismus case.

The two phases of abnormal retinal correspondence are (1) bimacular separation of the images and (2) macular-comacular superimposition of the images. In bimacular separation, the two macular images are not superimposed but separated. They are projected to different points in space. Thus, bimacular separation is present instead of bimacular superimposition. This phase is diagnosed by the after-image test. In the second phase, there is actual superimposition of the macular image in the fixing eye and the comacular image in the deviating eye. There is even some evidence of a sort of fusion. This phase is diagnosed by comparison of the objective and subjective angle of squint. The three possibilities in testing the two phases of correspondence and noncorrespondence are:

1. Bimacular separation of images (abnormal correspondence) and comacular superimposition of images (abnormal correspondence). This phase is deep seated and the orthoptic prognosis is not good.

2. Bimacular superimposition of images (normal correspondence) and macular-comacular superimposition of images (abnormal correspondence). In this phase monocular diplopia is more easily aroused and orthoptic prognosis is good.

3. Bimacular separation of images (abnormal correspondence) and macular-comacular separation of images (normal correspondence). Monocular diplopia is more easily aroused and orthoptic prognosis is good.

12-4

*Starkiewicz, Witold: *Value of different tests of retinal correspondence and the influence of rotation of the head on the after-image test,* Klinika Oczna, 21:35-40, 1951.

Fifteen patients with convergent and six with divergent squint were examined by means of the after-image test in the positions of adduction and abduction of the eyes. The author found that the after-image test frequently indicates false correspondence in cases where other tests show normal correspondence. Turning the patient's head influences the result obtained with the after-image test. The after-image test showing false correspondence may be the first indication of breaking down of normal correspondence.

Sylvan Brandon

13-1

Urist, Martin J.: *Surgical treatment of esotropia with bilateral elevation in adduction,* Arch. Ophth., 47:220-247 (Feb.) 1952.

The purpose of this paper is to show the surgical results in cases of esotropia with bilateral elevation in adduction. Four possible procedures are listed by the author.

1. Bilateral recession of the medial recti—best surgical results in reducing apparent overaction of these muscles.

2. Bilateral resection of the lateral recti—poorest results and often caused an exotropia for distance and residual esotropia for near.

3. Recession and resection of one eye—good procedure only when the angle of deviation is the same looking up or down.

4. Recession of the inferior oblique combined with horizontal muscle surgery—not good as a primary procedure because (a) the elevation is bilateral and the recession causes increase in the opposite type of vertical deviation, (b) the vertical deviation may be only secondary to a horizontal and (c) this recession may add a paretic vertical component to these vertical deviations.

Surgical procedures on the lateral rectus have the greatest effect on distance and upward positions of gaze, while the medial rectus procedures affect the near and down positions of gaze.

Cases treated with each of these procedures are presented and the results of each type of operation are clearly given.

14-1

Cibis, Paul A.: *Faulty depth perception caused by cyclotorsion,* Arch. Ophth., 45:31-42 (Jan.) 1952.

An attempt is made to show that under certain circumstances, faulty depth perception is due to cyclotorsion.

The cause and need for cyclotorsion is explained and some norms were given for range of cyclotorsion.

The author (1) investigated range and frequency distribution of cycloincongruities within a normal group of persons and (2) studied factors likely to evoke cyclotorsion.

Charts, graphs and tables show the results of tests and certain basic conclusions are drawn by the author.

14-2

*Marquez, M.: *True and false ocular torsion,* Arch. oftal. Buenos Aires, 26:15-25 (Jan.-Feb.) 1951.

The author analyzes the different types of torsion. True torsion is a rotation around an anteroposterior axis; such movements are not made normally as they would serve no useful purpose. They occur only in pathologic conditions, when there is an imbalance between the muscles which produce torsion, mainly the oblique muscles. In true torsion the anterior hemisphere of the eye turns in the same direction as the posterior hemisphere. The projection of the retinal image in the affected eye (in cyclotropia) is opposite to the rotation of the eye.

False torsion results when the eye rotates on one of the axes in Listing's plane. In this movement the anterior hemisphere and the posterior hemisphere of the eye move in opposite directions, and the projection of an after-image is in the same direction as the rotation of the meridians of the posterior hemisphere. These meridians have rotated in the same direction as the direction of gaze. Donders and Helmholtz wrongly interpreted these movements, having confused the axes of the eye with the meridians of the posterior hemisphere which pass through the fovea, and which alone are important in the projection of the after-image.

Joseph I. Pascal

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